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THE EFFECT ON MARGINAL SEAL OF VENEERING Dicor® SUBSTRATES WITH Dicor® PLUS PORCELAIN

A

THESIS

Presented to the Faculty of

The University of Texas Graduate School of Biomedical Sciences

at San Antonio

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

By

Maurice Regan Salamander, D.D.S.

San Antonio, Texas

May, 1991

THE EFFECT ON MARGINAL SEAL OF VENEERING Dicor® SUBSTRATES WITH Dicor® PLUS PORCELAIN

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May 17, 1991
Date

APPROVED:

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DEDICATION

This thesis is dedicated to my family. To my wife, Debbie, whose love, commitment, sacrifice, and spiritual strength gave me the time and freedom to complete this work. To my daughters, Nicole and Rakel, for their love and understanding.

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I am eternally grateful to our Lord Jesus, through whom all things are possible (1 Corinthians 1: 4-9; Philippians 4: 13).

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THE EFFECT ON MARGINAL SEAL OF VENEERING Dicor® SUBSTRATES WITH Dicor® PLUS PORCELAIN

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A clinical crown preparation on a maxillary right central incisor dentoform tooth was made. Forty standardized wax patterns for a Dicor® crown (control) and two different coping designs were cast, cerammed, and fit to their respective gypsum dies. Dicor® Plus porcelain was applied to half of the specimens of two different substrate designs. All restorations were tacked to their respective dies to permit measurement of the marginal seal with a measuring microscope. The casting-die assemblies were embedded in clear resin, sectioned faciolingually and mesiodistally, then measured in cross-section.

Dicor® restorations have acceptable physical properties, are locally and systemically biocompatible, have clinically acceptable fit, and, within the limitations of surface coloration, are esthetically pleasing. However, surface coloration does not take full advantage of laminated, multilayer porcelain build-up techniques. These techniques make possible the reproduction of

more complex and intricate internal color characterizations seen in natural teeth. For this reason Dicor® Plus porcelain was developed. The purpose of this study was to evaluate the effect on marginal seal of firing Dicor® Plus porcelain to two different Dicor® substrate designs.

In the frontal view there were no statistical differences in mean marginal openings between the Dicor® crown controls or the two substrate designs with or without Dicor® Plus porcelain. In the cross-sectional view there were statistically smaller mean marginal openings on the mesial and distal sides for certain groups compared to the Dicor® crown controls. Since the measurements were smaller this is probably not clinically significant.

The Dicor® substrates appeared to behave much like metal copings. They cast better where they were thicker (lingual) and there was more distortion interproximally and facially than lingually.

Based on this investigation, Dicor® Plus porcelain may be fired to a Dicor® substrate design as recommended by the manufacturer or to a more extensively cutback design without adversely affecting marginal seal.

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I. INTRODUCTION AND LITERATURE REVIEW

A. Historical perspective

Since the desire to esthetically replace lost or defective tooth structure was first expressed, man has resorted to a variety of materials in pursuit of this goal. Over the years, wood, wire, metal, acrylic resin, porcelain, metal-resin restorations, metal ceramic restorations, and all-ceramic restorations have been used in dentistry. A look at the evolution of dental porcelain might begin with the French apothecary, Alexis Duchateau's first set of all mineral denture teeth constructed in 1774. These teeth were relatively white and opaque. It wasn't until 1838,when Elias Wildman refined dental porcelain, that artificial teeth became more translucent and closer in shade to natural teeth.

The first use of porcelain-fused-to-metal technology was in 1806 when the Italian, Giuseppangelo Fonzi, baked platinum brackets inside porcelain teeth and gold soldered them to a platinum denture base. Most dental ceramic work at that time was associated with complete denture construction. Then, in 1817, Plantou introduced porcelain denture teeth into the United States (Jones, 1985).

However, single tooth porcelain restorations did not appear until around 1844. Many individuals tried to improve these restorations, but it wasn't until 1880 that the Richmond crown emerged as a real improvement. Five years later in 1885, Logan simplified the fabrication technique by adopting Fonzi's porcelain-fused-to-metal technology to a post crown. Dr. C.H. Land of Detroit reportedly was the first individual to successfully fuse porcelain to a burnished platinum foil matrix for crowns and inlays in 1886. Even with improvements, the technique involving metal and porcelain was too difficult for most to master and interest waned (Jones, 1985). Brecker (1956) observed that color and form instability of "plastics in crown and bridge," annoyance at fractured porcelain, and "insistent demands by patients for esthetics" were good reasons for dentistry to resume the use of "fused porcelain in restorative dentistry." At the same time, research in this area was underway (Johnston et al., 1956) and has continued through the present day.

The history of casting dental porcelain is more recent. Douglas Wain (1923) reported being able to cast porcelain the same way one would cast gold. There were a few alterations though. Fusion of the porcelain was accomplished by centrifugal casting with an "ordinary gas blow pipe." The sprue former was thicker than that used for alloys and the investment and casting apparatus was kept "hot" during casting. The products name was Castporlain and Wain claimed it would fuse to porcelain teeth and all metals except zinc or alloys containing zinc. He noted that cavity preparation had to be altered by making non-bevelled "square margins." As for fit, he reported it comparable to fused porcelain inlays, that is, "the cement line shows." Castporlain's use was primarily in esthetic areas, hence, it came in "23 shades including gum pink."

Fenn (1932) reported essentially the same technique but he used a Steele's facing in combination with a metal post. He ground the facing to fit the root at the gingival margin then he used inlay wax to join the post and facing. If he thought the "bite" was close he would have the patient close into the wax "whilst soft." The reported advantages of the technique were:

> "(i) A very strong crown with a much more accurate fit than is possible with any other crown except a cast gold base. (ii) The root does not require any accurate preparation. (iii) Translucent. The color of the facing is not darkened or altered in any way. (iv) Great savings in operative time as there is only a thin edge of porcelain to grind to fit. (v) Cheap."

The cast glass-ceramic Dicor® also had it's roots in the 1930s. Fredrick Carter of the Steuben Division of the Corning Glass Works applied the lost wax casting principle to glass. It wasn't until the late 1950s and 1960s that this would be pursued by dental researchers. MacCulloch (1968) reported on the discovery by S. D. Stookey in 1959 of adding a small quantity of a nucleating agent (metal phosphate) to certain molten glasses. If, after the glass had solidified, it was reheated to almost it's softening temperature, crystals would form around the metal nuclei. The resultant product was white in color, had a higher melting point, and was stronger than the parent glass. This new type of material was given the name glass-ceramic.

MacCulloch varied the shade by altering the ceramming time and temperature. He ingeniously added character by using silver as the nucleating agent. This modification rendered the glass-ceramic photosensitive allowing him to differentially apply ultra-violet light. After ceramming, the teeth had acquired the same polychromatic effect as natural teeth. At that time, he applied this particular technology to the fabrication of denture teeth.

Hench et al. (1971) investigated investment and casting variables which would improve casting "glass-ceramic inlays, crowns, bridges." He reported being able to routinely obtain "sharp margins and good fit."

In the succeeding years, particularly between 1977 and 1984, research in this area intensified and culminated with the introduction of the Dicor® cast glass-ceramic restorative material in 1984. Corning Glass Co., Peter J. Adair, and later Dentsply International are credited with its development (Adair et al., 1980; Grossman, 1985; Malament, 1988; Sulik, 1989)

B. Dicor® - Composition and Physical Properties

Dicor® is a castable machinable glass that can be formed into crowns, onlays, inlays, and veneers by the lost wax technique. Its initial form is completely translucent and fragile and requires ceramming to transform it to a usable state for dental applications. The ceramming process converts the vitreous glass to a crystalline glass-ceramic by this heat treatment procedure (Grossman, 1985; Craig, 1989). Once cerammed, shading porcelain is applied to the external surface of the restoration for shade development.

Dicor®'s base composition is: SiO_2, K_2O, and MgO, with Al_2O_2 and ZrO_2 added for durability, plus MgF_2 - providing a fluoride component, and a fluorescing agent for esthetics. Combined these ingredients form a tetrasilicic fluoromica glass ceramic: $K_2Mg_{2.5}Si_4O_{10}F_2$ (Grossman and Walters, 1984).

1. Cerammed Layer

Viewing a cerammed casting from it's external surface to it's internal aspect, the material may be described as follows (Bailey and Bennett, 1988; Campbell and Kelly, 1989): 1) Ceramming causes an opaque layer to form at the glass investment interface. Enstatite ($MgSiO_3$) crystal "whiskers", 25-100 micrometers (μm) long and 50μm thick, are oriented perpendicular to the investment and may be seen in the white cerammed "skin." This white layer also represents a zone of macro and micro subsurface porosity.

2. Parent Material

Below the white cerammed layer, is the parent material consisting of tetrasilicic fluoromica crystals approximately 1μm thick and 5-6μm in diameter enveloped in a glassy matrix. The crystals occupy 55% (by volume) of the structure, while the glass matrix accounts for the remaining 45% of the volume. Feldspathic porcelain, by comparison, is mostly a mass of amorphous glass with 12-15% crystals (by volume).

Because of their small size and increased number, the Dicor® crystals form an interlocking network that aids in stopping Griffith's flaw propagation. The result is a two-fold increase in the modulus of rupture and a nearly five-fold increase in compressive strength compared to feldspathic porcelain (Table 7). Conversely, fatigue in ceramics is the subcritical growth of cracks aided by a combined influence of water and stress. It has been estimated that fatigue failure is a possibility in feldspathic porcelain after remaining in water at 37^{o}C for 5 years (Morena et al., 1986). In addition to possible ceramic fatigue, Dicor®'s zone of porosity may be a source of structural weakness (Campbell and Kelley, 1989). Stresses are also introduced during cementation from hydraulic pressure. Though one would think Dicor®'s die spacing system could help alleviate this, it was discovered that die spacing reduced seating time but not deformation. What does help, is a passive fit of the crown on the tooth (Wilson et al., 1990).

Campbell and Kelley (1989) evaluated the effect of three surface preparations on the flexural strength of Dicor® and the microstructure of the prepared surfaces. Their experimental groups were: #1. As cast and cerammed. #2. Cut back by .2-.3 millimeters (mm) on one side with fine rotary diamonds, then polished with a porcelain adjustment kit and .2μm diamond polishing paste. #3. As cast, cerammed, and etched with 10% ammonium bifluoride for one minute. #4. As cast, cerammed, and four layers of Dicor® shading porcelain applied. Analysis of the data showed the cut back group was significantly stronger than the other three groups. The mean flexural strength was 22,420 ± 3,815 psi which is close to the value reported by the manufacturer. The shading porcelain group showed the lowest mean strength (11,848 ±

2,878 psi) which is very close to that reported for feldspathic porcelain. Fractographic analysis of the broken test bars and clinically failed Dicor® restorations revealed the zone of subsurface porosity associated with the cerammed layer as the primary origin of failure. Removal of .2 to .3 mm from the test bars would have removed the white cerammed layer and its associated zone of porosity since this "skin" is only 25-100 μm thick. This may have accounted for the two-fold increase in flexural strength reported.

3. Wear

If occluding surfaces of restorations are "all-ceramic", they would necessarily have the potential to oppose natural dentition. This brings to mind the question of wear. Multiple investigations have been done concerning wear. Palmer et al. (1988), in an in vitro study, concluded that Dicor® restorations should not be glazed in areas of occlusal contact. Moffa et al. (1988) said that control of crown thickness and occlusion are critical to clinical success. They also reported that over a 3 year period, Dicor® clinical restorations were found to be "durable, extremely esthetic, possessed excellent marginal fit, biocompatibility, and there was no degradation of the overlying shading porcelain." It can be deduced from this that there was: 1. No opposing occlusion, 2. The material opposing this was of equal microhardness, 3. The opposing surface had a microhardness less than that of Dicor® and, therefore, it was wearing and not the Dicor® shading porcelain. Delong et al. (1989), in an in vitro study, reported that unglazed Dicor® was the least abrasive ceramic compared to an Olympia metal control. Jacobi et al. (1989) indicated that the Dicor® parent material was the least abrasive of the ceramics tested but more abrasive than Type III gold by a factor of 10. Naylor et al. (1990) evaluated Dicor® microhardness under different surface treatments. They concluded that "the cerammed and polished surface was the hardest state of Dicor® and harder than human enamel. Shaded Dicor® had a surface hardness comparable to dental porcelain; however,the parent Dicor® material beneath the shading porcelain had a knoop hardness similar to enamel." Palmer et al. (1991) reported that hardness may not be a reliable indicator of wear. Their in vitro study compared wear against human enamel from cerammed Dicor® with and without shading porcelain and conventional dental porcelain. They found shaded Dicor® produced significantly more wear than unshaded Dicor® or conventional feldspathic porcelain. Cerammed Dicor® produced less wear than dental porcelain but it was not statistically significant. However, parent Dicor® material below the cerammed layer was not tested.

From this review of the literature concerning wear and Dicor®, it would be advantageous to establish occluding surfaces in polished Dicor® parent material. This portion of the Dicor® restoration appears to be more compatible with enamel than other ceramic materials.

Other physical properties of interest are those reported by Pameijer et al. (1980), Grossman (1985), Malament (1988), and Campbell (1990): 1. Translucency is an aid to quality control. After casting and divestment, the non-crystalline precerammed vitreous glass may be viewed for unacceptable porosities, voids, or inclusion bodies which would make the restorations unacceptable. Cast alloys may be viewed only through specific radiation analysis for the same defects, 2. Cast glass-ceramic has a relatively high compressive strength (Dicor® 828, enamel 400, amalgam 379, and dental porcelain 172 MPa). Its microcrystalline structure allows it to absorb true compressive forces, 3. It is more thermal resistant than metal ceramic restorations (Dicor® .004, amalgam .05, and gold .7 cal/sec/cm^2/^{o}C/cm), 4. It is radiolucent, thus, tooth structure and marginal integrity may be viewed beneath a crown, 5. Because the casting investment mold and castable glass are both silicates, the glass reportedly wets the investment to a greater extent than casting alloys, 6. Color stability of the shading porcelain is reported permanent and, 7. Dicor® is machinable and polishable.

Dicor®'s linear coefficient of thermal expansion is reportedly compatible with that of aluminous porcelain (Dicor® 7.2, aluminous porcelain 7.0, feldspathic porcelain 14 ($10^{-6}/^oC$) (Geller and Kwiatkowski, 1987; Campbell, 1990). The linear coefficient of thermal expansion is defined as the fractional increase in length of a body for each degree centigrade increase in temperature (McCabe 1990). This property is particularly relevant to this investigation. Hobo and Shillingburg (1973) recommended $1x10^{-6}/^oC$ as the optimum difference for porcelain-metal systems. Craig (1989) suggested only a 0.5 to $1x10^{-6}/^oC$ difference. The important point is that the veneering ceramic should have a linear coefficient of thermal expansion slightly less than its substructure. This places the ceramic in compression rather than tension upon cooling. Though the difference in the coefficient for Dicor® and aluminous porcelain is $1.2 \times 10^{-6}/^{\circ}C$, these hybrid crowns have been commercially available since 1985 (Geller and Kwiatkowski 1987; Sanderson 1988). The linear coefficient of thermal expansion for Dicor® Plus porcelain is reportedly more closely matched to Dicor® than aluminous porcelain, but the exact figures have not been published (Vryonis and Watkins 1989).

C. Biocompatibility

Physical properties are only one concern in the search for improved dental materials. Before any product can be used clinically, it must be shown to be biocompatible in humans. The body has to accept these materials both locally and systemically.

The biocompatibility of Dicor® was established according to the procedures outlined in ANSI/ADA document No. 41 (Grossman, 1985; Wohlwend et al., 1989). Grossman and Walters (1984) also reported that Dicor® was more resistant to strong acids and water than regular dental porcelain and equally resistant to stain.

When one discusses biocompatibility in an intraoral environment, included in the discussion must be the material's relationship with dental plaque and the material's location, contours, and surface texture.

1. Plaque Retention

Dental plaque is an aggregate of microorganisms embedded in an organic intercellular matrix. It forms not on the tooth but on the pellicle attached to the tooth. The pellicle is the result of restorations showed the lowest affinity for soft debris accumulation. It was also noted that increasing the ceramic veneer surface area decreased plaque retention. Block (1987) reported different materials retain plaque differently especially if located subgingivally. Adamczyk and Spiechowicz (1990) did a similar study and found the largest quantities of dental plaque were retained on metallic restorations and this plaque was closely packed in thick layers. In contrast, glazed porcelain was observed to have the smoothest surface and it had the least amount of plaque. This plaque was loosely packed. This phenomenon seems to be associated with ceramic materials in general. Dicor® restorations with shading porcelain have also been shown to have decreased plaque formation (Grossman, 1985; Savitt, 1987; Savitt, 1988).

Margin placement and contour are also related to periodontal health. Becker and Kaldahl (1981) reported that the more supragingival the margin, the healthier the tissue. Gardner (1982), in a review of the literature, summarized that gingival inflammation is associated with subgingival margins. Schmidt and Brown (1989) reviewed that restorations that violate soft tissue attachment cause tissue inflammation and attachment loss. They recommended margin placement "short of" the coronal aspect of the epithelial attachment. Block (1987) recommended placing margins .5 mm into the sulcus to facilitate patient oral hygiene efforts and to avoid contact with the "attachment complex." Grasso et al. (1985) reported, that rather than margins, oral health response relates to inadequate embrasures and contours. They found that "nearly half" the cast restorations they examined were overcontoured. Grossman (1985) postulated that tissue health associated with Dicor® restorations was due to a lack of an opaque layer. Besides being coarse-grained and rough, he noticed that when there is no opaque layer there is less tendency to overcontour a restoration. Perhaps the most pragmatic point of view concerning crown contours was that by Hunter and Hunter (1990):

> "The ability of dental technicians to produce anatomic crown contours while working to the minimum possible thickness of material has been overestimated."

They further hypothesized that inadequate tooth preparation is the primary reason for overcontouring. Eames (1981) observed that what one gets in reality is often contrary to that proposed in theory. He found that castings returned from the dental laboratory were elevated from the tooth by an average of 200 micrometers. This brings to mind questions concerning margin design and fit.

D. Margin Design and Fit

Hunter and Hunter (1990a), quoting Ostbund, reiterated that "fit... has become an intense preoccupation." Quoting Donovan and Prince (1985):

> "Optimum margin design would be esthetic, exhibit excellent marginal closure, and present materials at the gingival margin that resist the adsorption of dental plaque."

But, anytime one attempts to describe, measure, and present the results to others, one must do so with universally accepted terms. Unfortunately, research terminology is not universal. Holmes et al. (1989) observed, that "often the same term is used to refer to different measurements, or, different terms are used to refer to the same measurement." This observation is all too apparent to those who read scientific literature, and it is often the reason for the difficulties in comparing the results of studies. In order to clarify terminology, this investigator adopted conceptually, those terms used by Gavelis et al. (1981), Gulker (1985), and Hunter and Hunter (1990b). That is, marginal seal is defined as the horizontal discrepancy observed at right angles to the two opposing surfaces, those being,in this investigation, the gypsum die and the margin of the seated restoration (Figure 3).

Gardner's 1982 literature review provided evidence to support casting relief. Without the use of mechanical or chemical casting relief or die spacers, castings failed to seat, with marginal openings in excess of 100 micrometers. It is not easy to ascertain from the literature what a clinically acceptable margin is. Hunter and Hunter (1990) reported studies that ranged from 25 to 120 micrometers. In Christensen's classic 1966 study, 10 restorative dentists were unable to consistently evaluate gingival margins with explorers and radiographs. Gingival margins up to 119 μm were deemed acceptable. Yet, the mean gingival margin in that study was 74 μm. To the contrary, occlusal and/or proximal openings of 26 μm were rejected by these same ten evaluators. Christensen predicted the least acceptable margin to be 39 μm using a linear regression prediction formula. Hung et al., (1990) suggested 50 to 75 μm as the range of clinical acceptability. Studies cited to date have used complete gold and/or metal ceramic crowns for these measurements.

The literature available for Dicor® restorations is equally ambiguous. At least a dozen studies over the past 10 years have been published. Numerical values for marginal openings ranging from 15 to 87 micrometers have been reported. Qualitative verbal results have also been reported. Most of the reports have been of laboratory studies using Bureau of Standard dies, clinical preparation dies, or other standard research dies. The results of those studies of Dicor®, in chronologic order by year, are as follows:

1980

Pameijer et al., stated: "marginal adaptation compares favorable to gold restorations."

1982

Adair and Hoekstra (1982) reported casting accuracy of Dicor® was comparable to dental casting alloys.

1986

Dentsply (1986) reported mean facial openings of 23 μm and mean lingual openings of 33 μm for anterior clinical crown patterns.

1987

Sorenson and Okamoto (1987) compared Cerestore, Dicor®, and Vita dur N all-ceramic crown systems. Using a measuring microscope they reported mean marginal openings of 15, 19, and 36 μm respectively.

Holmes, et al. (1987) compared Dicor® margins to those produced in Type III gold. He luted the castings to their dies with an unfilled resin, thereby removing the cement factor. Facial lingual, mesial, and distal measurements were combined. The combined mean marginal opening for the Dicor® restorations was 48 ± 7 μm. Type III gold measured 57 ± 19 mm.

Rappold et al. (1987) had three clinicians grade, as acceptable or unacceptable, the fit of class II Dicor® inlays before and after cementation using three different cements. All were graded as acceptable.

1988

Malament (1988) showed a 15 μm gap on a metal Bureau of Standards die. He also pointed out that this could be expected "if attention is paid to detail during the laboratory procedures."

Davis (1988) found facial measurements of 37.3 ± 19.3 μm and lingual measurements of 38.0 ± 13.4 μm. He determined that die spacer is essential because of inadequate setting and/or thermal expansion. The glass shrinks approximately 1.6% when cast. Though there is a compensatory expansion during cerámming, die spacing is needed to further compensate for casting shrinkage.

Schaerer et al. (1988) measured cement film thickness of 87 ± 17.7 μm facially and 79 ± 20.7 μm lingually. They attributed this to rounded, irregular margins caused by four factors: 1. Shrinkage during ceramming. 2. A change in surface texture after ceramming, 3. the surface white layer and its removal, 4. Damage from air abrasives after casting, ceramming, and removal of the white layer.

It must be noted here that Wohlwend et al. (1989) showed conclusively the profoundly adverse effect that air abrasion could have on Dicor® margins. In figure 15 of their article, a wedge shaped piece of Dicor® shows substantial rounding from air abrasives.

1989

McInnes-LeDoux et al. (1989) studied shear bond strengths with different luting agents and different surface treatments. They concluded that resin cements provided the highest bond strengths to Dicor®, enamel, and dentin. From this they hypothesized that the success of Dicor® restorations with resin cements may be more dependent on the restoration's fit than on the luting agent used. Evidently, the resin undergoes polymerization shrinkage, thereby making microleakage a potential problem. However, the better the fit, the less cement required, therefore, less shrinkage will result.

Abbate et al. (1989) reported on eight investigators examining fit, margin design, and distortion from repeated firing. They found that marginal fit of complete crowns with a 120 degree shoulder, rounded axiogingival line angle, and 5 degrees of axial taper, in cross section, was 65.3 ± 17.5 μm. Measurements were made at 100, 200, and 300 micrometers from the external margin.

1990

Al-Saif et al. (1990) evaluated Dicor® shoulder and chamfer finish lines both with 1 or 2 sprues for an MOD onlay on a maxillary first premolar. The shoulder design was the best and it made no difference as to number of sprues. Yet the three operators judged only 50% of the castings as clinically acceptable.

Hung et al. (1990) compared Dicor®, Cerestore®, and metal ceramic crowns. Before cementation the mean vertical marginal discrepancy (seating) for each of these crowns was 50, 48, and 38 μm respectively. These figures were taken from a graph and represent the combined midfacial, midlingual, midmesial, and middistal measurements.

E. Marginal Distortion

Another factor to consider when evaluating marginal fit is the effect of each component in a multiple component system. In the

1950s, when interest in "fused porcelain" was renewed , this consideration was one of the first pondered. What happens, if anything, to the metal substructure during porcelain application and does it effect crown fit? Johnston et al. (1956) considered the possibility of metal warpage during porcelain sintering. Silver et al. (1960) discovered, in fact, porcelain shrinkage could actually buckle metal if the coping was less the .5 mm thick. Mumford (1965) proposed four reasons for this distortion: 1. Contraction of porcelain with subsequent metal deformation, 2. Contamination of the casting, 3. Grain growth of the alloy. 4. Porcelain fired to the internal surface of the casting. Shillingburg et al. (1973) observed that metal copings didn't fit as well after porcelain was fired to them. They tested four margin designs - chamfer, heavy chamfer with bevel, shoulder with bevel, and shoulder. Their axial reduction was 1.2 mm. The metal surface to be veneered was .35 mm thick with opaque fired to a thickness of .3 mm. Body and incisal porcelain were added and the crowns were given a final glaze. Measurements were made before firing, after oxidizing, after opaqueing, after both first and second body bakes, and after final glazing. All margin designs exhibited openings with the addition of porcelain. Shoulders, with and without levels, exhibited the least amount of opening at 5.8 and 10.7 micrometers respectively. Also in 1973, Hobo and Shillingburg found that metal copings were subject to flow or creep when heated. They suggested the difference between the melting temperature of the metal and the fusion temperature of the porcelain be as great as possible. As a minimum they suggested a

300 to 500^{o}F temperature differential. Faucher and Nicholls (1980) also recognized distortion from porcelain application and they attempted to quantify the magnitude and location of this distortion. Their margin designs were chamfer, shoulder, and bevelled shoulder. Labial axial reduction was 1.5 mm so they could use a veneering surface .5 mm thick. The opaque layer was .3 mm thick. They also found distortion occurring for all margin designs and throughout the different firing cycles. Bevelling made no significant difference. The extent of marginal opening from porcelain application for the various finish lines were: chamfer - .11 μm, shoulder - .09 μm, and bevelled shoulder - .062 μm. McLean and Wilson (1980) discovered that resistance to creep was dependent on the cross-sectional area of the metal collar with or without a bevel. They suggested a flat shoulder as opposed to a bevelled shoulder and a collar width of.5 mm or greater. Buchanan et al. (1981) postulated distortion was due to repeated firing. Metal oxide formation during oxidation was also a possibility. Bridger and Nicholls (1981) studied distortion of fixed partial dentures. Their results showed metal frameworks used at that time distorted after oxidation from sagging and internal stress relief. Also, rapidly cooling glass had a greater tendency to contract than slower cooling glass. Stresses from differing coefficients of thermal expansion were more pronounced during rapid cooling. Hamaguchi et al. (1982) investigated the clinical significance of this distortion. They examined chamfers, with and without bevels, and shoulders, with and without bevels. They measured the fit of the facial margin before porcelain

application, after the final glaze, and after acid stripping the porcelain from the coping. They maximized external validity by not attempting to standardize procedures as technicians don't standardize procedures under everyday laboratory conditions. Coping thicknesses were measured with calipers and were between .25 to .30 mm. Their results showed changes for all designs in the range of 0 to 10 μm. This was reported to be clinically insignificant. They also made the observation that "the "open" margin of PBM crowns is probably due to the technical difficulty in forming a knife-edge margin of metal and porcelain than to any distortion due to porcelain shrinkage." Donovan and Prince (1985) considered distortion a complex phenomenon related to the metals used, the difference between the melting temperature of metal and fusion temperature of porcelain, and the geometry of margin configuration. Wanserski et al. (1986) evaluating the direct lift technique for porcelain-labial margins, reported "pyroplastic deformation during firing."

Literature cited to this point has concerned metal ceramic systems. The majority of these reports indicate that porcelain veneering procedures can cause distortion in a metal ceramic restoration. The clinical significance of this effect, in terms of fit, remains questionable. These same concerns exist for all-ceramic systems as well. Regarding Dicor® restorations in particular, Grossman (1985) reported marginal stability during shading porcelain applications. Malament and Grossman (1987) contended that "cast glass-ceramic may be fired repeatedly in a conventional glazing oven without affecting the properties or marginal integrity." Though not proven to date, this could very well be true. The difference between the casting temperature for the glass and the fusion temperature for the shading porcelain is 784.8°F (436°C). This finding is consistent with Hobo and Shillingburg's (1973) recommendation of a temperature separation between 300 to 500°F or greater. Dicor® shading porcelain is applied in very thin layers then fired. Typically, four applications are required to attain the desired shade. This results in a shading porcelain approximately 125 μm thick.

The shading porcelain is not a simple stain, but colorants blended into a feldspathic porcelain host. It physically and chemically bonds to its glass-ceramic substrate. Microprobe analysis across the interface reportedly has shown an exchange of potassium and sodium ions between materials (Malament and Grossman, 1987).

F. Esthetics

The pursuit of the ultimately esthetic restoration has been a driving force since dentistry's inception. Entire textbooks and journals have been devoted exclusively to this subject. Since 1984, at least 5 different all-ceramic systems have been developed and marketed worldwide (Wohlwend et al. 1989). Walton (1986) reported that of 270 patients he examined because of prosthodontic failures, 11.3% sought treatment to replace restorations with poor esthetics. There are a number of factors to consider in esthetic metal ceramic restorations. Natural teeth reflect, absorb, and transmit light. But metal ceramic restorations mostly absorb and reflect light. The metal substructures of these restorations prevent light transmission. This results in a more opaque and less vital appearance. Restorations with metal collars compound the problem further because of high specular reflections at the gingival margin from thin body porcelain over coarse-grained opaque (Donovan and Prince, 1985). Initial clinical studies have shown Dicor® crowns to be esthetically pleasing (Adair, 1982; Grossman, 1985; Geller and Kwiatkowski, 1987; Malament, 1988). This esthetic success is partially due to a reported chameleon effect, whereby light is transmitted through the restoration from adjacent structures, i.e., teeth, restorations, and supporting structures (Adair, 1982; Yamamoto, 1985; Malament, 1988). The increased number and decreased size of mica crystals with a nearly matched index of refraction to the surrounding glass phase, cause less intense light scattering. This, along with no opaque layer and one piece construction result in greater translucency at the gingival margin without impedance of light scatter (Grossman, 1985; Sulik, 1989).

Dicor®'s elimination of an opaque substructure solves some esthetic problems, but at the same time, introduces a whole new set of others. According to Campbell (1990) these are:

1. Surface shading of translucent glass.
2. No true "depth of color." Shading porcelain is only 125 μm thick.

3. Chairside contour adjustments may remove this thin layer exposing the "white" layer or translucent glass beneath it.
4. Inherent translucency.
5. High value, low chroma shades require less surface colorant. This combined with the darkness of the oral cavity may lower the value and give a restoration a gray appearance.
6. Minimal control over surface texture.

The Dicor® system also relies on cement color to achieve the restoration's final shade. Additionally, the Dicor® technique does not take advantage of the multilayered and laminated build-up techniques necessary to create the many effects seen in natural teeth (Geller and Kwiatkowski, 1987; Yamamoto, 1985).

In order to deal with discoloration of soft tissues and/or the cervical black line of metal collared metal ceramic restorations (Yamamoto, 1985; Donovan and Prince, 1985; Gordner, 1986; Bertolotti, 1987), Geller and Kwiatkowski (1987) developed a hybrid crown system that veneered a Dicor® substrate with aluminous porcelain. This hybrid crown has reportedly met with clinical success (Geller and Kwiatkowski, 1987; Sanderson, 1988; Campbell, 1990). Adair (1982) reported that Dicor® was compatible with aluminous porcelain. In late 1989,Dentsply International Inc. introduced Dicor® Plus porcelain, which reportedly is a "modified" aluminous porcelain more thermally compatible with the Dicor® substrate than aluminous porcelains such as Vita Dur N (Vita, Vident) (Vryonis and Watkins, 1990).

If one accepts the fact that Dicor® crowns have acceptable physical properties, are systemically and locally biocompatible, fit reasonably well, and are, within the limitations of surface shading, esthetically pleasing, what happens to marginal seal of Dicor® substrates veneered with Dicor® Plus porcelain? The purpose of this investigation was to determine if veneering two different Dicor® substrate designs with Dicor® Plus porcelain affects marginal seal as compared to conventional Dicor® crowns.

G. Null Hypothesis

The marginal seal of Dicor® Plus porcelain veneered crowns is similar to the marginal seal of conventional Dicor® crowns and Dicor® copings without Dicor® Plus porcelain veneering.

II. MATERIALS AND METHODS

The experimental design was based primarily on the works of Arnold and Aquilino (1988) and Brukl and Philp (1987).

A. Fabrication of Wax Patterns

1. Crown preparation

An Ivorine tooth of a maxillary right central incisor (tooth number 8) (Columbia Dentoform, Columbia Dentoform Corp, Long Island City, New York) was prepared according to the Dicor® Clinical Instructions Manual (Dentsply International Inc., 1987). A clinical preparation was used to maximize external validity and more closely approximate how the materials might react using intraoral preparation guidelines (Arnold and Aquilino, 1988; Schaerer et al., 1988; Davis, 1988). The tooth was reduced as follows: facially 1.5 mm, lingually 1.0 mm, mesially 1.0 mm, distally 1.0 mm, and incisally 2.0 mm. All points and line angles were smoothed and rounded.

Once the preparation was completed, the Ivorine tooth was augmented at its base with a 1 mm thick piece of Moyco Beauty Pink extra hard wax (Moyco Industries, Philadelphia, PA) to allow the gypsum die to be sectioned and standardized in length. Total length was 19 mm from its base to the tip of the preparation. A second piece of wax 8x9x1 mm was added to facilitate pouring and removal of the gypsum dies.

2. Metal die

After augmentation, the Ivorine tooth was impressed in a split mold (see Section II.A.4.) and a wax pattern was generated for metal die fabrication. A metal die establishes a stable baseline from which multiple working dies may be generated. It is also more resistant to abrasion from multiple impression procedures thus ensuring more standardized working dies. The wax pattern generated was invested in Hi-Temp, a non-carbon, phosphate-bonded investment (Whip Mix Corp., Louisville, KY). A Rexillium III (Jeneric/Pentron Inc., Wallingford, CT) casting was made, finished, and polished to resemble the prepared Ivorine tooth (Plate 1).

3. *Gypsum dies*

Eight impressions were made of the master metal die. Rigid clear plastic church communion cups were used as trays. They were painted with the appropriate tray adhesive and filled with Mirror 3 Extrude, a Type 1 medium viscosity addition silicone impression material (Kerr Manufacturing Co., Romulus, MI). The metal die was coated with Mirror 3 Extrude impression material and immersed in the tray. The impression was allowed to bench set for 15 minutes. The eight impressions were poured five times each with Silky-Rock, an ADA certified Type IV dental stone (Whip mix Corp) (Lacy et al., 1981a; Lacy et al., 1981b; Johnson and Craig, 1985). Fifty grams of powder to 11.5 milliliters of distilled water were vacuum mixed, poured, and allowed to set for 60 minutes prior to removal from the impressions. After the dies were removed, the bases were cut off and the dies adjusted with sandpaper to the final length of 19mm.

4. Split mold

Wax injection molding into a split mold was used to standardize wax pattern replication (Naylor, 1990; Minke, 1990; West et al., 1985; Compagni et al., 1984; Dunkin, 1972).

The split mold consisted of an indexed dental stone cop and drag system (Plate 2). The dental stone housed an addition silicone impression of the wax pattern-die assembly. A lubricated gypsum die was placed in the split mold. The two halves of the mold were put together and secured with a heavy duty rubber band. Molten wax was injected with a wax injector (Procraft, GFC, Carlstadt, NJ) (see Section II. A. 6.). After cooling, the resultant wax pattern-die assembly was removed and the process repeated until forty wax patterns were produced.

5. Wax patterns

A gypsum cast replica of the dentoform was made by pouring Silky-Rock into an impression made with Mirror 3 Extrude in a custom tray (plate 3). Tooth #8 was left out of the dentoform so a socket would be available to accept individual gypsum dies.

A full contour complete crown wax-up (Mave's #2 green stick inlay wax, Mave's Co., Cleveland, OH) was sculpted to represent the pattern for a control Dicor® crown. This wax pattern was then sprued according to the Dicor® Laboratory Manual. An 8 gauge 3mm long direct sprue was attached to the wax pattern. A 15mm sprue former rod was then luted to this direct sprue. The sprue-pattern-die assembly was subsequently impressed in a split mold described in Section II.A.4. From the Dicor® crown split mold, two full contour crown patterns were injection molded (Procraft) in Mave's green stick inlay wax. From these two patterns, the two coping designs were generated.

a. Coping design #1- Alternate coping

This coping was designed to produce a minimum amount of Dicor® coping material and a maximum amount of veneering porcelain. The coping design appears in Figure 1 and has the following dimensions:

-Incisal thickness of 0.5mm Dicor®.

-Lingual thickness of 0.5mm Dicor® with a lingual overlap 2mm apical to the incisal edge of the coping.

-Facial thickness of 0.5mm Dicor®.

-Interproximal cutback was 2mm lingual to the contact area.

-A 0.5mm Dicor® collar.

b. Coping design #2- Dicor® Plus coping

This coping design was made according to the Dicor® Plus porcelain system technique manual. The design appears in Figure 2 and has the following dimensions:

-Incisal thickness of 1.0mm Dicor®.

-Lingual thickness of 0.7mm Dicor® with a lingual overlap 1mm apical to the incisal edge of the coping.

-Facial thickness of 0.8mm Dicor®.

-Interproximal cutback preserved the contact area in Dicor® coping material.

-A 0.5mm Dicor® collar.

Once the 2 coping patterns were sculpted, split molds were made for each pattern (Section II.A.4.).

Figure 1. Alternate Coping Design

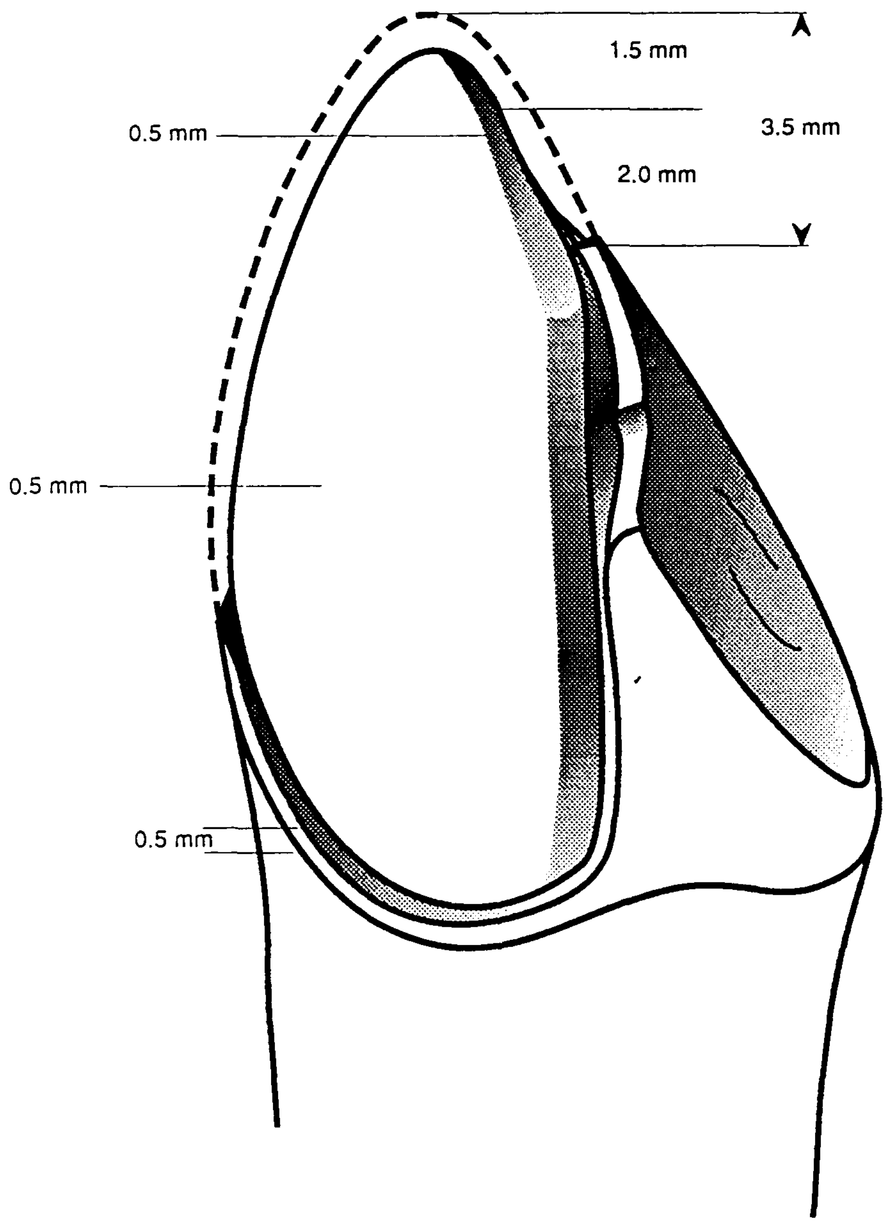
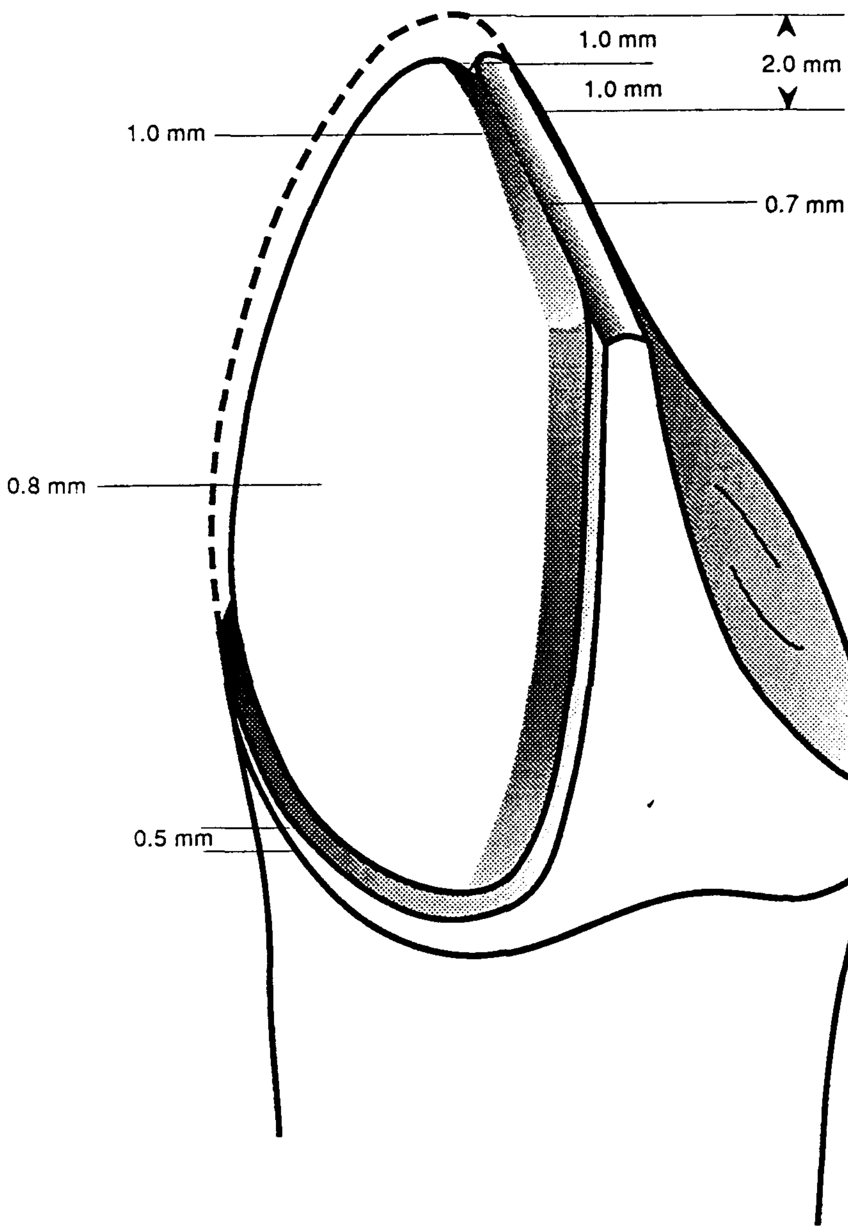


Figure 2. Dicor® Plus Coping Design



6. Injection molding

The wax injector (Procraft) was filled half full with Mave's green stick inlay wax. The exact melting range of the wax was not possible to measure, because wax at the top of the pot was semi-molten while the wax at the bottom was completely molten. The wax was drawn from the bottom but the actual injector protruded slightly above the rim of the pot. This further complicated temperature measurement. The proper temperature setting was determined during the pilot study phase using the lowest temperature setting that produced a smooth, complete wax pattern. This setting was physically marked on the wax injector for repeatability.

The three split molds (Dicor® control, alternate coping, and the Dicor® Plus coping) were rotated during the injection process. As one pattern was cooling the next was being injected until all forty patterns were generated. The exact procedure was as follows:

7. Die spacing

Dicor® die spacer (shade YB) was applied according to the Dicor® Laboratory Technique Manual:

a. A new bottle was shaken for 1 minute prior to opening.

b. The die spacer was applied with a small artists brush.

c. Vertical brush strokes starting at the gingival-axial line angle were used to apply the die spacer . Periodically, two drops of Dicor® die spacer solvent were added to the bottle if the die spacer became thickened. Again,the bottle was shaken for 1 minute prior to further application.

d. All forty dies received one application of die spacer prior to any die receiving a second application. All dies had two applications of die spacer prior to wax pattern fabrication. After die spacing was completed, Die Sep (Penwalt/Jelenko, Armonk, NY) was applied and allowed to sit 10 minutes prior to wax injecting. Dies were randomly selected, placed in a split mold, and wax injected until eight Dicor® crown patterns, sixteen Dicor® Plus coping patterns, and sixteen alternate coping patterns were generated.

B. Crown and Coping Fabrication

Three wax patterns, a complete crown and one each of the two coping designs, were processed each day until all forty had been made. One wax pattern was invested and cast per casting ring to avoid casting error due to position in the ring.

1. Coding and investing

Identification codes were placed on both the wax pattern and its corresponding die. A sharp pointed dental explorer was used under magnification to carve codes into an individual wax pattern,while on it's gypsum die. A sharpie marker was also used to code the gypsum dies. The codes used were as follows:

D = Complete Dicor® crown

C = Alternate coping design only

CP = Alternate coping with porcelain

+ = Dicor® Plus coping only

+P = Dicor® Plus coping with porcelain

A number ranging from 1 to 8 was added to each of the eight samples per cell i.e. +P6 represented the 6^{th} sample in group +P (Dicor® Plus coping with porcelain).

This procedure was performed under x20 magnification (Vision Master; Glenn Products, Inc., Ft. Lauderdale, FL) immediately prior to investing. A 3mm, 8gauge direct wax sprue former was attached to the incisal edge of the patterns. An 11 mm diameter sprue former rod was luted to this direct sprue former. The assembly was adjusted until it was 5 mm from the top of the round casting ring (1 13/16" x 1 1/2"). Two layers of slightly damp ceramic ring liner (Kaoliner, Dentsply International, Inc.) were placed with the smooth side toward the ring. A 67.5 gm package of Dicor® Castable Ceramic Investment (batch #083389101) was hand mixed with 9 ml of distilled water for 30 seconds in a new Vacuspat bowl used only for Dicor® investment. The investment was vacuum spatulated for an additional 30 seconds, after which, the wax pattern was painted, and the casting ring slightly overfilled. This was allowed to bench set 1 hour.

2. Wax Elimination

The excess investment was removed from the top of the casting ring. Three casting rings were placed in a room temperature Accutherm II 2000 burnout furnace(Penwalt/Jelenko). Two of the rings were placed near the rear corners and the third ring was positioned near the center of the oven. A two-stage wax elimination technique was used. The rate of rise was approximately 15°F/ minute for both stages. Stage one was room temperature to 250°C with a 30 minute hold time. The stage two temperature ranged from 250^{O}C to 980^{O}C with a 30 minute hold time before casting.

3. Casting

Due to special equipment and technique sensitivity, casting of the Dicor® ingots was done by a trained Dicor® technician in a Dicor® authorized laboratory. The procedure used was that outlined in the Dicor® Laboratory Technique Manual. The casting arm was balanced to accommodate the casting ring size used in this study. The muffle was checked for debris and cleaned, if necessary, while at room temperature. Idling procedures were followed and the oven was allowed to idle at 1100^{O}C for 60 minutes. A properly handled cartridge containing the 4 gm glass ingot was positioned in the muffle. A melting temperature of 1376^{O}C was set and the melt switch activated. Once melting temperature was reached the ingot was held for 6 minutes at temperature then cast. The casting procedure was accomplished within 15 seconds. After the spin time, the casting ring was removed and the next two rings were cast in a similar manner. The last casting ring was allowed to bench cool for 60 minutes. All three rings were then divested.

4. Divesting

After removal from the casting ring, the bulk of investment was carefully removed by hand. The remaining investment was removed with Faskut 25 micrometer aluminum oxide (Dentsply International, Inc.) under 40 psi in a non-recycling abrasive unit (Microblaster, Comco, Inc, Burbank, CA). Though Wohlwend et al., (1989) showed the adverse affect of air abrasives on a margin shaped Dicor® casting, the manufacturer recommends it's use.

Hence, it was used in this study. After removal of the remaining investment an ultrathin cut-off disk was used at slow speed to remove the button followed by a Busch Silent Stone for gross sprue removal. Final contouring was done with fine laboratory diamonds and water at slow speed. Castings were then gently air abraded and ultrasonically cleaned in distilled water for 10 minutes prior to embedding.

5. Embedding

The Dicor® ceramming tray was wetted with distilled water prior to mixing the embedment. A ratio of 3.5 ml distilled water to 10 gm of embedment was used. The embedment material was mixed for 30 seconds then loaded into the tray. The crown and copings were filled, inverted, placed margins down, and completely covered with embedment material. The embedment material was allowed to set for 30 minutes. Twenty castings were embedded at one time and the process was repeated for the remaining twenty.

6. Ceramming

Two trays, the one on the bottom being empty, were placed in the ceramming furnace. Two pieces of Kaoliner, with one Dicor® ceramming cone on each, were positioned in opposite corners of the tray with the embedded castings. The ceramming furnace was activated and the ceramming process took approximately 10 hours to complete. Once the furnace cooled to 200°C the ceramming tray was removed and cones checked for proper droop. The trays were then allowed to cool to room temperature before breakout.

The cerammed restorations were removed with finger pressure. The remaining embedment was air abraded with Faskut 25 micrometer aluminum oxide at 40 psi.

7. Fitting

Obvious casting nodules were removed under x20 magnification with fine laboratory diamonds at slow speed. The die spaced surfaces of the dies were soaked for 60 seconds in acetone to loosen the die spacer. Cotton tip applicators soaked in acetone were used to remove the die spacers prior to fitting the castings. Red Occlude (Pascal, Bellevue, WA) was sprayed on the individual dies. The castings were gently seated with light finger pressure and removed for inspection. Areas requiring relief were examined under x3.5 magnification and relieved with fine laboratory diamonds at slow speed. The process was repeated until no further seating was detected and until the die and casting could be inverted with the casting falling off with a light tap on the die (a passive fit).

8. Porcelain application

All porcelain applications and heat treatments were done in a Vacumat 100 porcelain furnace (Vita Zahnfabrik, Bad Säckingen, Germany).

a. Dicor® crowns

Each crown was air abraded with 25 micrometer Faskut aluminum oxide and ultrasonically cleaned in distilled water for 10 minutes. Prior to shading porcelain application the castings were heat treated by being placed in the furnace with a 2 minute entry time, fired from 600 to 940^{o}C and held for 3 minutes without vacuum. Dicor® Shading Porcelain D-A3.5 and D-E34 were mixed to a honey like consistency with Dicor® Shading Porcelain Medium. Dentsply Crown Holders were used to hold the crowns during porcelain application. Each coat of shading porcelain was applied with the manufacturer's supplied brush. The firing schedule for each coat was the same as the heat treatment schedule. A total of 4 coats of Dicor® Shading Porcelain were applied and fired separately.

b. Dicor® Plus Porcelain

The gypsum cast replica of the dentoform described in Section II.A.5. and a gypsum contour index made from the complete crown wax-up was used as a duplication guide to standardize porcelain shape. Eight copings from the Dicor® Plus coping group and eight copings from the alternate coping group were randomly chosen for porcelain application.

The copings were air abraded with Faskut 25 micrometer aluminum oxide at 40 psi and ultrasonically cleaned for 10 minutes in distilled water prior to heat treating. The porcelain furnace was set at 700^{o}C with a preheat cycle of 3 minutes and the copings were fired to a temperature of 940^{o}C with a 3 minute hold time in air. The copings were bench cooled prior to inspection.

Dicor® Plus A3.5 and E-4 porcelains were mixed with Dicor® Plus Porcelain Medium to a good working consistency. Two separate porcelain applications were made, requiring two firing cycles. After minimal shaping, the crowns were air abraded and ultrasonically cleaned in distilled water for 10 minutes and then glazed. The firing schedule for the body bake was: furnace idled at 600°C, drying time of 3 minutes, and firing to a high temperature of 950°C with a 1 minute hold time under 28 inches of mercury vacuum. Glazing followed the same schedule except the high temperature was 930°C with no vacuum.

9. Etching and coupling

All 40 completed specimens went through the etching and coupling procedure. Bailey and Bennett (1988) showed that Dicor® etched with 10% (w/v) ammonium biflouride (NH_4HF_2) and treated with heat cured beta-methacryloxypropyltrimethoxysilane produced the best resin bond. The ammonium bifluoride is a less hazardous etchant than hydrofluoric (HF) acid. Only four restorations were etched at a time due to the timing of the process.

Four castings were placed in a tysine block incisal edge down. Ammonium bifluoride Dicor® Etching Gel was placed internally and left in place for one minute. The crowns were steam cleaned under lightly running water for 15 seconds and air dried with pressurized oil-free air for 15 seconds. One drop of Dicor® Coupling Agent (silane esters) was mixed with the appropriate amount of distilled water in the provided mixing bottle. The bottle was shaken for 30 seconds and allowed to stand for 5 minutes. A glass eyedropper was used to place the 0.1% solution in the crowns. The solution stood for 3 minutes. After blow drying for 15 seconds, the crowns were placed in a 100°C furnace for 30 minutes. The chemically cured silane esters were used because resin bond strength was not a factor in this study. Chemically cured silane esters also require a shorter application time.

C. Casting Resin Investment

1. Tacking

An unfilled composite resin was used to tack each coping or crown to its respective gypsum die (Holmes et al., 1987). This was done to keep the marginal seal area clear of any resin. Resin in this area made measuring difficult during the pilot study. One half drop of Prisma Universal Bond (Caulk/Dentsply, York, PA) was placed on the incisal edge of the die. The die was carefully inserted into the casting and the crown was seated by hand. The casting-die assembly was placed in a constant load apparatus with the load being 390 grams (plate 5). An Optilux 400 Model VCL 400 (Demetron Research Corp., Danbury, CT) was used to polymerize the resin 60 seconds facially then 60 seconds lingually. After tacking down the castings, the marginal opening of all 40 restorations were measured from the frontal view (see Section II.E.).

2. Casting Resin Investment

After measuring marginal opening, the casting-die assemblies were invested in casting resin in preparation for sectioning. One inch sections of 3/4" diameter polybutyrate plastic tubing (Plastic Supply Co., San Antonio, TX) were cut to receive the casting resin. These sections were placed on pieces of 2 mm thick plastic sheets (Splint Biocryl, Great Lakes Orthodontics, Tonawanda, NY) that were cut to fit inside a large Vacuspat alginate bowl. The blade assembly was removed from the Vacuspat lid and replaced externally with an addition silicone putty plug to maintain a vacuum. Eight specimens were invested at one time.

In order to make sectional cuts and measure the specimens in the same location in cross-section as was measured in the frontal view, a Sharpie extra fine marker (Sanford Co.) was used to index the dies. Each die was positioned in the sectioned polybutyrate tubing such that the center of the incisal edge was in the center of the tube and the Sharpie index marks on the die were in line for the sectioning. The tube was removed and the die secured to the plastic sheet. The tubing was positioned and secured with rope wax so that the specimen was centered as described above.

Once eight specimens were secure on plastic sheet, the casting resin was mixed. The ratio used was two ounces of casting resin to 12 drops of hardener (Castin' Craft Clear Liquid Plastic Casting Resin, ETZ, Fields Landing, CA) mixed by hand for 30 seconds. This mixture was poured in each section of tubing. The plastic sheet was placed in the vacuspat bowl and held under 780 mm Hg for 5 to 7 minutes for three reasons. First, the vacuum removed air trapped in the gypsum die from areas to be sectioned and replaced it with resin. Second, it removed air in the space between the crown and the die and replaced it with resin. This was especially critical for the margin area. Third,this procedure secured the gypsum to the castings and prevented any displacement during quarter sectioning. The vacuum was slowly released and the sections were allowed to set for 24 hours.

D. Sectioning the Resin Embedded Specimens

The polybutyrate tubing served only as a matrix and was removed by splitting one side with a knife. Each specimen was placed in an alignment jig. An Isomet Plus precision saw with a high concentration diamond wafering blade (12.7 cm x .4 mm x 12.7 mm) was used for sectioning (Buehler Ltd, Lake Bluff, IL). The load used was 270 grams at a speed of 700 rp·. Buehler lubricant was used during sectioning. The specimens were oriented in the jig so the Sharpie indexes were in the same plane as the diamond blade. To compensate for the thickness of the blade, the blade was offset approximately 0.5 mm. The samples were sectioned both faciolingually and mesiodistally.

E. Measuring

All measurements were made with a Unitron Universal Measuring Microscope at x100 magnification (Unitron Instruments, Inc, Plainview, NY). The measuring drums were marked in ten thousandths of an inch.

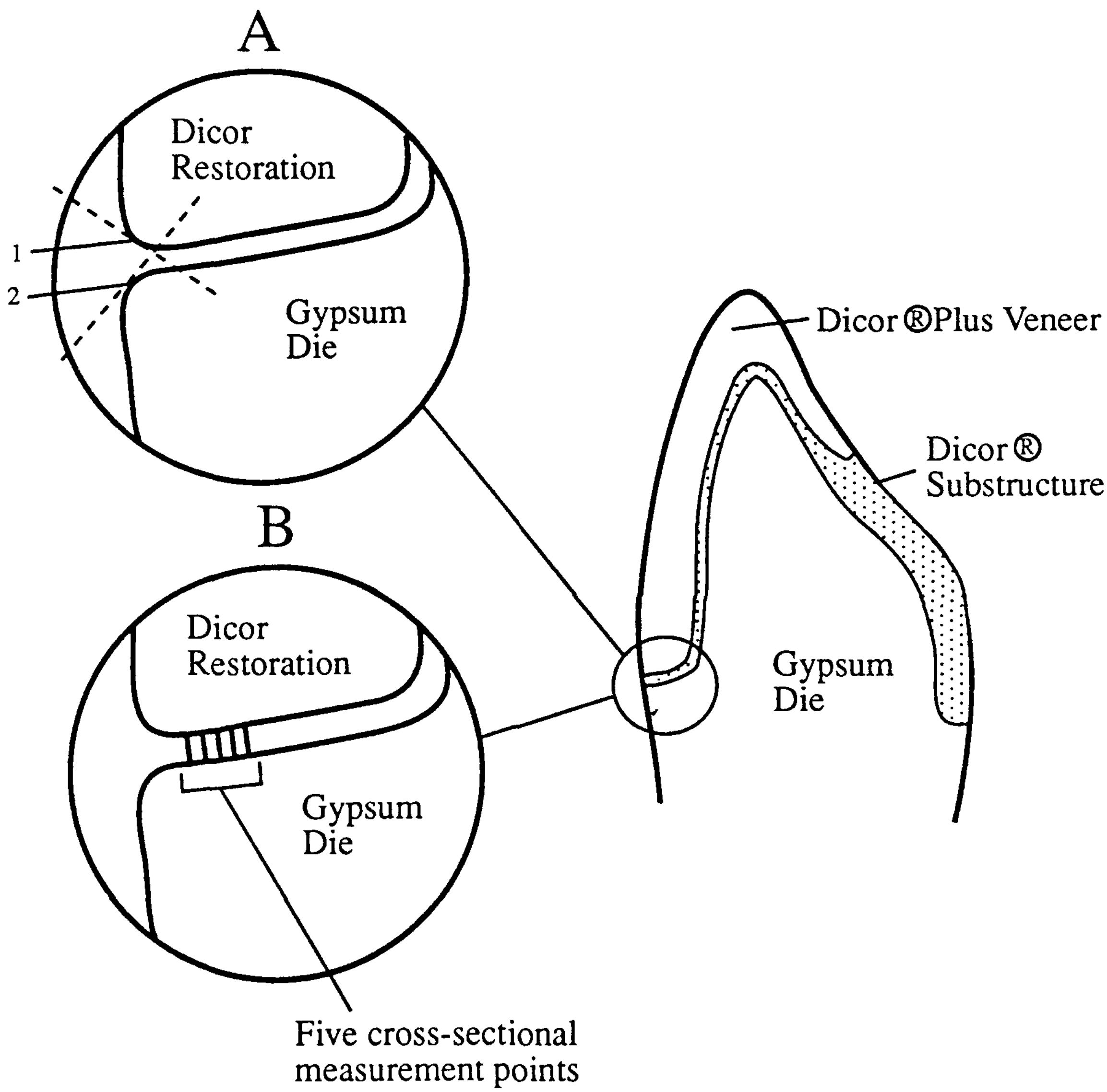
1. Frontal view marginal seal measurement

Once the specimens were tacked to their respective dies, they were measured in the frontal view. Five sets of points on each side - facial, lingual, mesial, and distal were measured (Figure

3). The facial and lingual centerpoints were those points at the greatest apical curvature of the margin. The mesial and distal centerpoints were those points that were at the greatest incisal curvature of the margin. These were determined by bringing the crosslines in the microscope eyepiece tangent to the most curved surface. This tangent point actually represented measuring point #3 as there were two points measured on each side of this centerpoint. There were 10×10^{-4} inches (25.4 micrometers) between each point. This distance was chosen because at any greater distance and at x100 magnification the image was not in focus due to the curvature of the specimens. Since the casting and die margins were rounded, the depth of field of the microscope was used in locating the points from which to measure (Figure 3). The procedure is described as follows.

Tysine blocks were used to position the specimens so the frontal plane of the margin and the frontal plane of the die were aligned and parallel to the objective lens of the microscope. The plane of the entire frontal surface of the casting was brought into focus. The point where rounding began went out of focus. One half the distance from the point of out-of-focus to the darkness representing the beginning of the cement space was used as a measuring point (Hung et al., 1990). A measurement was made and recorded on a data sheet. The same method was used to determine the measuring point on the die. A measurement was made and recorded on a data sheet.

Figure 3. Measurement Points



2. Cross-sectional view marginal seal measurement

After measuring the marginal opening from the frontal view, the specimens were invested, sectioned, and measured in cross-section (see Section II. C. and D.).

Tysine blocks were again used to position the specimens. The plane of the cross section was made parallel to the objective lens and verified by viewing the whole surface in focus. Again, five sets of points, each being 10×10^{-4} inches (25.4 μm) apart, were measured (Figure 3). The crossline in the eyepiece of the microscope was superimposed over the most apical portion of the casting. The point at which the Dicor® material started to curve superiorly away from the crossline was the first point of measurement. The intersection of the crosslines was moved to that point and a perpendicular dropped to meet the gypsum die. A second measurement was made. Four more sets of points were measured in an axial direction. All measurements were recorded on data sheets.

F. Statistical Analysis

Three-way factorial analyses of variance (2x2x4 ANOVA) with factors of porcelain (2 levels: with or without), design (2 levels: Dicor® Plus coping and an alternate design), and side (4 levels: facial, lingual, mesial, distal) were accomplished. Dunnett's multiple comparisons test was used to compare the four sides of each specimen in the non-control groups to the corresponding sides of the control group. The results of the analyses are listed in Tables 1 to 6.

III RESULTS

The sample size, means, standard deviations, analyses of variance, and Dunnett T test results are presented separately for data concerning the frontal view and cross-sectional view in Tables 1 through 6.

A. Frontal View

In the frontal view, the differences were not statistically significant ($p>0.05$) (Table 2). The Dunnett test also revealed no significant differences between any of the sides of the groups and the Dicor® crown controls (Table 3).

Though not significantly different statistically, there are notable differences that can be seen from examining the measurements of the mean marginal openings for the frontal view data in Table 1.

1. Comparing mean marginal openings by side

First, a comparison of the means of the Dicor® crowns, the alternate copings with porcelain, and the Dicor® Plus copings with porcelain, side for side, can be made.

The facial sides showed the Dicor® crowns to have the smallest mean marginal openings at 26.3208 ± 13.9462 μm followed by the Dicor® Plus copings with porcelain at 34.1504 ± 15.2689 μm and the alternate copings with porcelain at 45.4153 ± 13.6238 μm. The range of these means was approximately 19.1 μm.

The lingual sides demonstrated the alternate copings with porcelain to have the smallest mean marginal openings at 25.4064 ± 8.7424 μm followed by the Dicor® Plus copings with porcelain at 37.1476 ± 17.4330 μm and the Dicor® crowns at 39.0589 ± 30.3774 μm. The range of these means was approximately 13.7 μm.

The mesial sides of the Dicor® Plus copings with porcelain had the smallest mean marginal openings at 29.3942 ± 19.0101 μm followed by the alternate copings with porcelain at 33.3947 ± 13.4756 μm and the Dicor® crowns at 37.6619 ± 26.6397 μm. The range of these means was approximately 8.3 μm.

The distal sides demonstrated that Dicor® Plus copings with porcelain had the smallest mean marginal openings at 25.4890 ± 13.7057 μm followed by the alternate copings with porcelain at 39.5225 ± 15.0748 μm and the Dicor® crowns at 40.7734 ± 42.1521 μm. The range of these means was approximately 15.3 μm.

Considering the above mentioned mean marginal opening values, it can be seen that all means for all sides of both coping designs with porcelain are smaller than the means for the Dicor® crown controls except the means for the facial sides. Also, three of the four sides of the Dicor® Plus copings with porcelain had smaller means than the alternate copings with porcelain.

2. Differences of means for copings with and without porcelain

A second observation that can be made from Table 1, is a comparison of the differences of the means per side for copings with porcelain and without porcelain.

The alternate coping design demonstrated two sides where the addition of porcelain resulted in greater mean marginal openings compared to their without porcelain counterparts. The facial and distal sides with porcelain had greater mean marginal openings than without porcelain, whereas the mesial and lingual sides had smaller "with porcelain" mean marginal openings than without porcelain. Subtracting the mean marginal opening of the "with porcelain" group from the mean marginal opening "without porcelain" group for each side gives the following approximate differences: facial +5.5 μm, lingual -7.3 μm, mesial -10.0 μm, distal +1.0 μm. Positive differences indicate greater openings with the addition of porcelain compared to the same coping design without porcelain. Negative differences indicate decreased openings with the addition of porcelain compared to the same coping design without porcelain.

The Dicor® Plus coping design showed only one side where the addition of porcelain resulted in a greater mean marginal opening compared to it's without porcelain counterpart. The mesial side showed the only positive difference. Again, subtracting the mean marginal opening of the with porcelain group from the mean marginal opening without porcelain group for each side gives the following approximate differences: facial -1.5 μm, lingual -2.8 μm, mesial +1.5 μm, and distal -8.8 μm. Therefore, the addition of porcelain resulted in smaller mean marginal openings for the facial, lingual, and distal sides compared to their without porcelain counterparts.

B. Cross-Sectional View

Though the frontal view data showed no statistically significant differences, the cross-sectional view did.

In cross-sectional view, there were significant effects for porcelain ($p<0.05$) and side ($p<0.05$) (Table 5). The combined mean marginal opening and standard deviation for the "with porcelain" group was 20.8837 (± 15.1656) μm. The combined mean marginal opening and standard deviation for the "without porcelain" group was 16.2044 (± 11.9832) μm. Therefore, in the cross-sectional view, considering all 64 sides combined, the "with porcelain" groups had significantly greater mean marginal openings than the "without porcelain" groups. At 20.8837 ± 15.1656 μm, this may not be clinically significant. The range of the means for the "with porcelain" group was from approximately 13.0 μm to 37.0 μm and the range of the means for the "without porcelain" group was approximately 10.3 μm to 30.0 μm.

1. Comparing mean marginal openings by side

Though not significantly different statistically, the facial sections of the Dicor® crowns, in cross-sectional view, had the smallest mean marginal openings at 19.8755 ± 10.4801 μm followed by the Dicor® Plus copings with porcelain at 30.1118 ± 21.2840 μm and the alternate copings with porcelain at 36.9761 ± 20.4280 μm.

The lingual sections demonstrated the Dicor® Plus copings with porcelain to have the smallest mean marginal openings at 15.5131 ± 11.9309 μm followed by the alternate copings with porcelain at 22.4600 ± 10.4405 μm and the Dicor® crowns at 23.1077 ± 17.2838 μm.

The mean marginal openings on the mesial side were statistically significantly smaller than the Dicor® crowns at $p<0.01$ (Table 6). The alternate copings with porcelain measured at 12.9858 ± 8.8887 μm followed by the Dicor® Plus copings with porcelain at 14.4653 ± 7.6655 μm and the Dicor® crowns at 31.9914 ± 18.6070 μm.

The distal sections showed no statistically significant differences (Table 6), but the mean marginal openings of the alternate copings with porcelain were slightly smaller at 16.9926 ± 13.2716 μm followed by the Dicor® Plus copings with porcelain at 17.5641 ± 8.8144 μm and the Dicor® crowns at 28.7211 ± 22.0117 μm.

The Dunnett test revealed a significantly smaller difference at the distal side between the alternate coping design without porcelain (10.2616 ± 7.0012) and the Dicor® crown control (28.7211 ± 22.0117) ($p<0.050$) (Table 6). All four experimental groups showed a significantly smaller difference on the mesial side when compared to the Dicor® control (Table 6).

TABLE 1

FRONTAL VIEW

Individual Cell Means, Standard Deviations, and Sample Size by Coping Design (in micrometers)

Dicor® CONTROL MEANS, STANDARD DEVIATIONS, AND SAMPLE SIZE

SIDE	MEAN	S.D.	N
FACIAL	26.3208	13.9462	8
LINGUAL	39.0589	30.3774	8
MESIAL	37.6619	26.6397	8
DISTAL	40.7734	42.1521	8

ALTERNATE COPING DESIGN

SIDE	PORCELAIN	MEAN	S.D.	N
FACIAL	No	39.9987	22.3379	8
	Yes	45.4153	13.6238	8
LINGUAL	No	32.7407	17.5317	8
	Yes	25.4064	8.7424	8
MESIAL	No	43.3007	46.0340	8
	Yes	33.3947	13.4756	8
DISTAL	No	38.5890	18.8800	8
	Yes	39.5225	15.0748	8

Dicor® PLUS COPING DESIGN

SIDE	PORCELAIN	MEAN	S.D.	N
FACIAL	No	35.6934	13.1979	8
	Yes	34.1504	15.2689	8
LINGUAL	No	39.9225	26.1299	8
	Yes	37.1476	17.4330	8
MESIAL	No	27.7813	23.1300	8
	Yes	29.3942	19.0101	8
DISTAL	No	34.2964	19.5987	8
	Yes	25.4890	13.7037	8

TABLE 2

FRONTAL VIEW

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	SUM OF SQUARE	DEGREES OF FREEDOM	MEAN SQUARES	F	PROBABILITY OF F
WITHIN CELLS	7394.36	112	66.02		
FACTORS					
PORCELAIN	38.90	1	38.90	.59	.444
COPING DESIGN	92.21	1	92.21	1.40	.240
SIDE	91.89	3	30.63	.46	.708
INTERACTIONS					
PORCELAIN BY DESIGN	.03	1	.03	.00	.983
PORCELAIN BY SIDE	37.98	3	12.66	.19	.902
DESIGN BY SIDE	316.18	3	105.39	1.60	.194
PORCELAIN BY DESIGN BY SIDE	91.98	3	30.66	.46	.708

TABLE 3

FRONTAL VIEW

MEANS AND STANDARD DEVIATIONS USED TO COMPUTE THE DUNNETT T TEST (N=8)

	FACIAL		LINGUAL	
	MEAN	S.D.	MEAN	S.D.
Dicor® CONTROL	26.3208	13.9462	39.0589	30.3774
ALTERNATE COPING	39.9987	22.3379	32.7407	17.5317
ALTERNATE COPING WITH PORCELAIN	45.4153	13.6238	25.4064	8.7424
Dicor® PLUS COPING	35.6934	13.1979	39.9225	26.1299
Dicor® PLUS COPING WITH PORCELAIN	34.1504	15.2689	37.1476	17.4330

	MESIAL		DISTAL	
	MEAN	S.D.	MEAN	S.D.
Dicor® CONTROL	37.6619	26.6397	40.7734	42.1521
ALTERNATE COPING	43.3007	46.0340	38.5890	18.8800
ALTERNATE COPING WITH PORCELAIN	33.3947	13.4756	39.5225	15.0748
Dicor® PLUS COPING	27.7813	23.1300	34.2964	19.5987
Dicor® PLUS COPING WITH PORCELAIN	29.3942	19.0101	25.4890	13.7057

TABLE 4

CROSS-SECTIONAL VIEW

Individual Cell Means, Standard Deviations, and Sample Size by Coping Design (in micrometers)

Dicor® CONTROL MEANS, STANDARD DEVIATIONS, AND SAMPLE SIZE

SIDE	MEAN	S.D.	N
FACIAL	19.8755	10.4801	8
LINGUAL	23.1077	17.2838	8
MESIAL	31.9914	18.6070	8
DISTAL	28.7211	22.0117	8

ALTERNATE COPING DESIGN

SIDE	PORCELAIN	MEAN	S.D.	N
FACIAL	No	30.0292	16.7159	8
	Yes	36.9761	20.4280	8
LINGUAL	No	10.7696	9.8044	8
	Yes	22.4600	10.4405	8
MESIAL	No	16.4084	8.7695	8
	Yes	12.9858	8.8887	8
DISTAL	No	10.2616	7.0012	8
	Yes	16.9926	13.2716	8

Dicor® PLUS COPING DESIGN

SIDE	PORCELAIN	MEAN	S.D.	N
FACIAL	No	23.0886	10.9056	8
	Yes	30.1118	21.2840	8
LINGUAL	No	12.5984	9.2250	8
	Yes	15.5131	11.0309	8
MESIAL	No	13.3063	5.4729	8
	Yes	14.4653	7.6655	8
DISTAL	No	14.1732	13.1618	8
	Yes	17.5641	8.8144	8

TABLE 5

CROSS-SECTIONAL VIEW

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	PROBABILITY OF F
WITHIN CELLS	2605.38	112	23.26		
FACTORS					
PORCELAIN	108.60	1	108.60	4.67	.033
COPING DESIGN	22.56	1	22.56	.97	.327
SIDE	879.90	3	293.30	12.61	.001
INTERACTIONS					
PORCELAIN BY DESIGN	3.23	1	3.23	.14	.710
PORCELAIN BY SIDE	50.28	3	16.76	.72	.542
DESIGN BY SIDE	53.00	3	17.67	.76	.519
PORCELAIN BY DESIGN BY SIDE	33.76	3	11.25	.48	.694

TABLE 6

CROSS-SECTIONAL VIEW

MEANS AND STANDARD DEVIATIONS USED TO COMPUTE THE DUNNETT T TEST (N=8)

	FACIAL		LINGUAL	
	MEAN	S.D.	MEAN	S.D.
Dicor® CONTROL	19.8755	10.4801	23.1077	17.2838
ALTERNATE COPING	30.0292	16.7159	10.7696	9.8044
ALTERNATE COPING WITH PORCELAIN	36.9761	20.4280	22.4600	10.4405
Dicor® PLUS COPING	23.0886	10.9056	12.5984	9.2250
Dicor® PLUS COPING WITH PORCELAIN	30.1118	21.2840	15.5131	11.0309

	MESIAL		DISTAL	
	MEAN	S.D.	MEAN	S.D.
Dicor® CONTROL	31.9914	18.6070	28.7211	22.0117
ALTERNATE COPING	15.4084*	8.7695	10.2616*	7.0012
ALTERNATE COPING WITH PORCELAIN	12.9858+	8.8887	16.9926	13.2716
Dicor® PLUS COPING	12.3063+	5.4729	14.1732	13.1618
Dicor® PLUS COPING WITH PORCELAIN	14.4653+	7.6655	17.5641	8.8144

* 5% Significance
\+ 1% Significance

TABLE 7

PHYSICAL PROPERTY DATA*

PROPERTY	Dicor® CAST CERAMIC	ENAMEL	FELDSPATHIC PORCELAIN
Density gm/cm^3	2.7	3.0	2.4
Refractive Index	1.52	1.65	
Translucency	0.56	0.48	.27
Thermal Conductivity $cal/sec/cm^2/^{o}c/cm$	.0040	.0020	.0030
Thermal Diffusivity mm^2/sec	.800	.469	.640
Modules of Rupture psi	22,000	1,500	11,000
Compressive Strength psi	120,000	58,000	25,000
Modules of Elasticity psi x 10^6	10.2	12.2	12.0
Microhardness KHN	369**	343	460

*Grossman (1985)

** Represents Dicor® polished parent material (Naylor,1990)

IV DISCUSSION

Coping design, margin design, and the linear coefficients of thermal expansion between porcelain and metal appear to be factors affecting distortion in metal ceramic systems. While this distortion in metal ceramics has been studied for over 30 years, it has not been as thoroughly evaluated in all-ceramic systems. Furthermore, what effect does this distortion have on marginal seal if it does occur? Consequently, this investigation was initiated to answer that question and to assess the basis for castable ceramic coping design.

As previously described, in the frontal view, mean marginal openings for all sides, except the facial side for the alternate copings with porcelain and the Dicor® Plus copings with porcelain, were smaller than the means for the control Dicor® crowns.

In the frontal view, addition of porcelain had a tendency to seal the external margin (a decreased mean marginal opening). Two of four sides for the alternate copings with porcelain showed smaller mean marginal openings than their without porcelain counterparts. The same tendency existed for the Dicor® Plus copings with porcelain. Three of four sides had smaller means than their without porcelain counterparts (Table 1).

In the cross-sectional view, just the opposite was true. For the alternate copings with porcelain three of four sides had increased marginal openings when compared to their without porcelain counterparts. For the Dicor® Plus copings with porcelain, all four sides had increased mean marginal openings when compared to their without porcelain counterparts (Table 4).

Therefore, if the external margins are sealing and the internal margins are opening, there must be distortion with the addition of porcelain. This may be due to the walls of the crowns bending or pursing ever so slightly in the vicinity of the crown margin. This behavior seems to parallel that for metal ceramic systems. In metal ceramic systems it was noted that the thinner the metal coping, the higher the probability for distortion (Silver et al., 1960; Wanserski et al., 1986). This distortion may not be clinically significant for marginal seal.

According to many reports cited in the literature, acceptable marginal fit measurements range from 25 to 120 micrometers (Hunter and Hunter, 1990b). If one accepts the middle ground range of 50-75 micrometers, as suggested by Hung et al. (1990), then the results of this investigation indicated that conventional Dicor® crowns and both Dicor® substrate designs used in this study, veneered with Dicor® Plus porcelain, should provide restorations with a clinically acceptable marginal seal.

A. Best and Worst Appearing Margins

After measurements were made in both views, the specimens were subjectively examined under x40 magnification. The "best" and "worst' appearing specimens for the facial, lingual, and an interproximal surface were photographed and appear in plates 7 to

18. Clinicians do not rely on statistics when examining a casting on a die. They visually examine the casting to determine its initial acceptability.

1. Frontal View

In the frontal view, plates 7,9,and 11, the specimens considered the best, in general, have a consistent, even appearance to their margins. Although,some margins appear more jagged than others, overall they are well adapted to the dies. Of more interest are those considered to have the worst marginal seal (plates 8, 10, and 12). There seemed to be two general patterns. One is an overall widening of the entire marginal area. The other is a more localized, confined, and abruptly wider opening in selected areas of the margin. This might have resulted from divestment procedures, air abrasives, or a defective wax pattern.

Of further interest, are areas of the gypsum die that appear chipped. These areas often correspond to microscopic positive casting nodules that were first noticed at x100 magnification under the measuring microscope. During the fitting procedure, even illumination was used. When viewing a cerammed casting, the opaque whiteness in combination with even illumination, made microscopic nodules virtually impossible to detect. When viewing these specimens with the naked eye, most of the above mentioned inaccuracies could not be routinely detected.

2. Cross-Sectional View

In cross-sectional view, plates 13, 15, and 17, the best margins appear to have a well adapted, consistent, and even appearance.

In plates 14, 16, and 18, which represent the worst samples in each category, there is a general widening of the space in the shoulder area. This may be due to bowing of the walls in the marginal area. Also, a slight increase in margin rounding can be seen. This is most likely the result of air abrasives.

In all cross-sectional views, plates 8 to 18, one can acquire an appreciation for the white cerammed skin produced during the ceramming process. The abrupt localized defects, viewed in frontal view plates 8, 10, and 12, probably occurred during divestment from the initial casting procedure. The vitreous glass is very brittle at this stage and air abrasives may inadvertently fracture the glass. Though air abrasives contribute to rounding (Felton et al., 1991), it doesn't appear that the entire white layer has been removed in any of the samples photographed. These photographs are only 2 dimensional, however.

The external surface of a Dicor® crown meets the shoulder surface at an angle less than 90°. This slightly acute angle approximates two cerammed surfaces and their associated zones of subsurface porosity (Campbell and Kelly, 1989). This weakened zone at an acute angle could possibly explain chipping and/or rounding from divesting, air abrading, and fitting procedures.

One other observation that can be made from plates 8 to 18, is that none of the castings appear to be overcontoured. There may be two reasons for this: 1) The shoulder margin design and,

2) The slight bowing of the walls from porcelain addition at the margin. As mentioned in the literature review, control of crown contours has a significant impact on periodontal health.

Hunter and Hunter (1990b) point out that structural rigidity is increased with a shoulder margin design. They also suggested, that during tooth preparation, minimum marginal width should be dictated by the dental materials used and maximum marginal width should be determined by preservation of tooth structure and pulp vitality. In this investigation, the fact that copings with porcelain fit statistically similar to those without porcelain suggests dimensional stability during the sintering of porcelain veneers.

V SUMMARY

The effect on marginal seal from firing Dicor® Plus porcelain on two different coping designs was investigated. Marginal seal measurements were made in a frontal view and a cross-sectional view with a measuring microscope. The results were compared to those obtained for a conventional Dicor® crown control group.

The following conclusions were drawn:

1. The mean marginal openings produced under the conditions of this investigation fell into the clinically acceptable range as reported in the literature. This was true for the conventional Dicor® crowns and both coping designs veneered with Dicor® Plus porcelain.
2. Though not statistically significant, the alternate copings with porcelain had larger mean marginal openings than the Dicor® Plus copings with porcelain in the frontal view. This was especially true for the facial side. Applied clinically, one would choose a coping design based on esthetic requirements. That is, if significant color characterization required an increased depth of veneering porcelain, the alternate coping design could be used, otherwise, the Dicor® Plus coping design should be adequate for most situations.
3. Although coping design is related to more factors other than marginal fit, this investigation substantiates the basis for

coping design recommended by the manufacturer and an alternate coping design.

4. These data applied only to the fit of Dicor® crowns and modified Dicor® restorations. Additional study is needed to determine the effect of the Dicor® substructure's design on the strength of the completed restoration.

PLATE 1

PREPARATION ON METAL DIE

FACIAL VIEW

LINGUAL VIEW

MESIAL VIEW

PLATE 2

SPLIT MOLD

PLATE 3

DENTOFORM GYPSUM REPLICA WITH CONTOUR INDEX

PLATE 4

SAMPLE SPECIMENS

(left to right)

Dicor® Crown, Alternate Coping, Alternate Coping with Porcelain

Dicor® Plus Coping, Dicor®Plus Coping with Porcelain

PLATE 5

CONSTANT LOAD APPARATUS

PLATE 6

SECTIONED SPECIMEN

Facial, Mesial, Distal, Lingual (left to right)

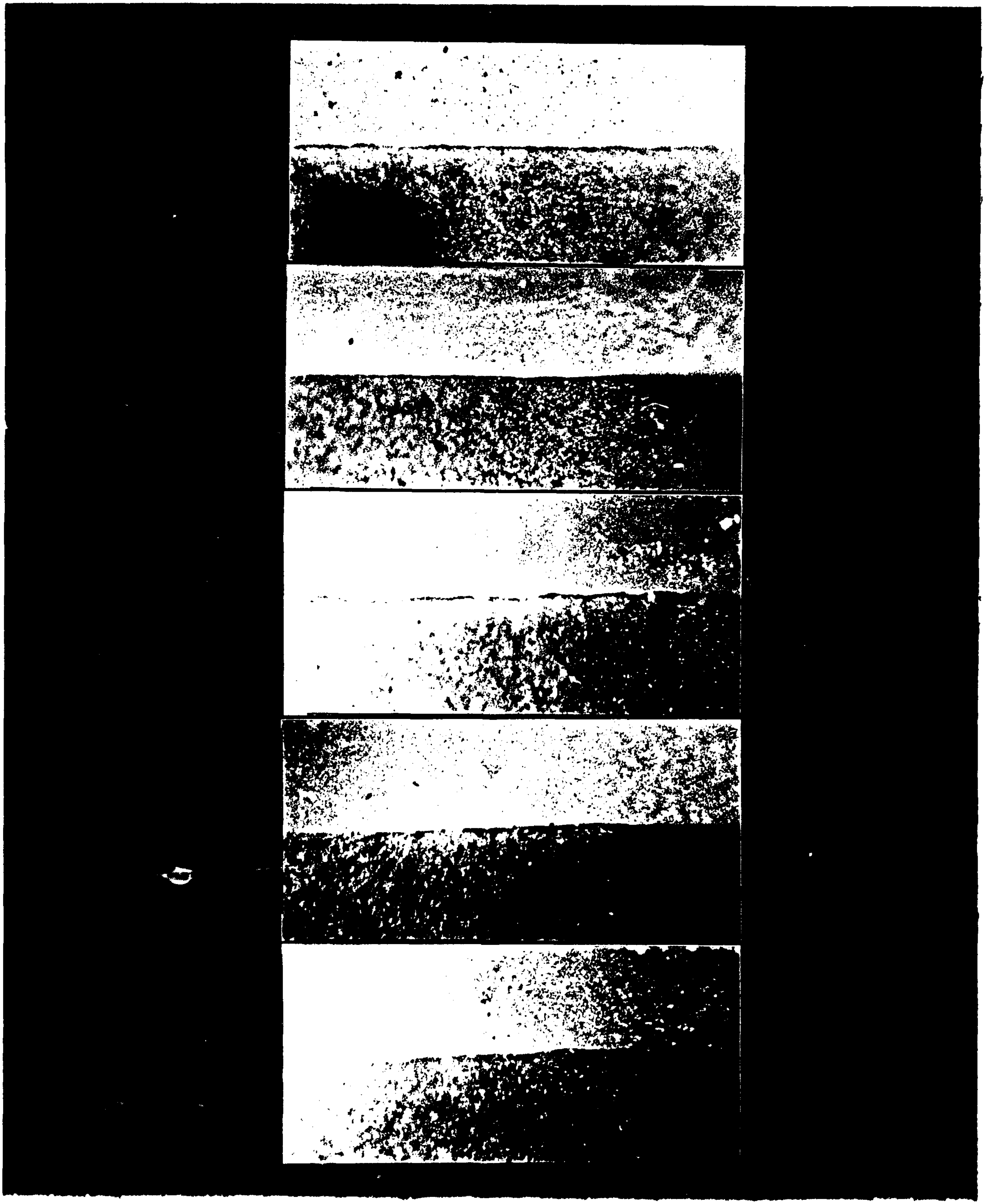


PLATE 7

FRONTAL VIEW

x40

BEST FACIAL SURFACES

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

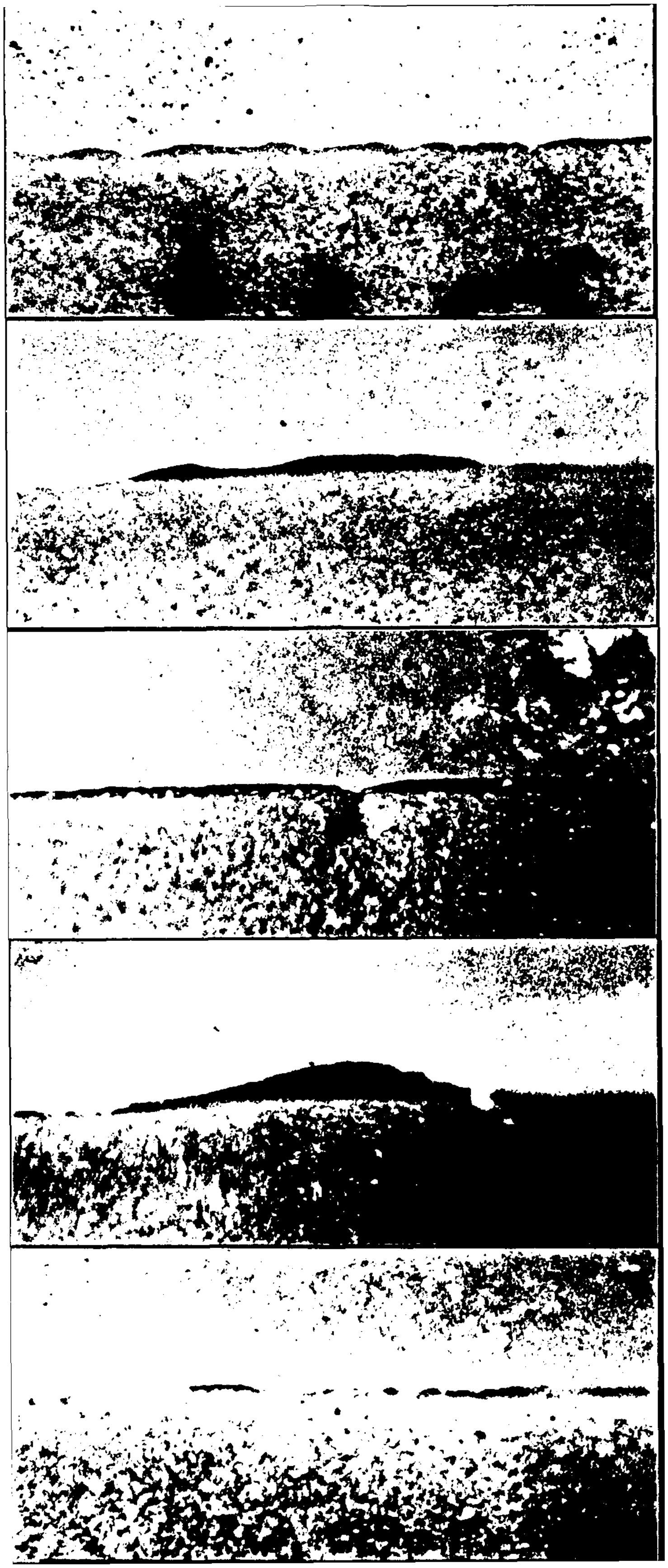


PLATE 9

FRONTAL VIEW

x40

BEST LINGUAL SURFACES

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

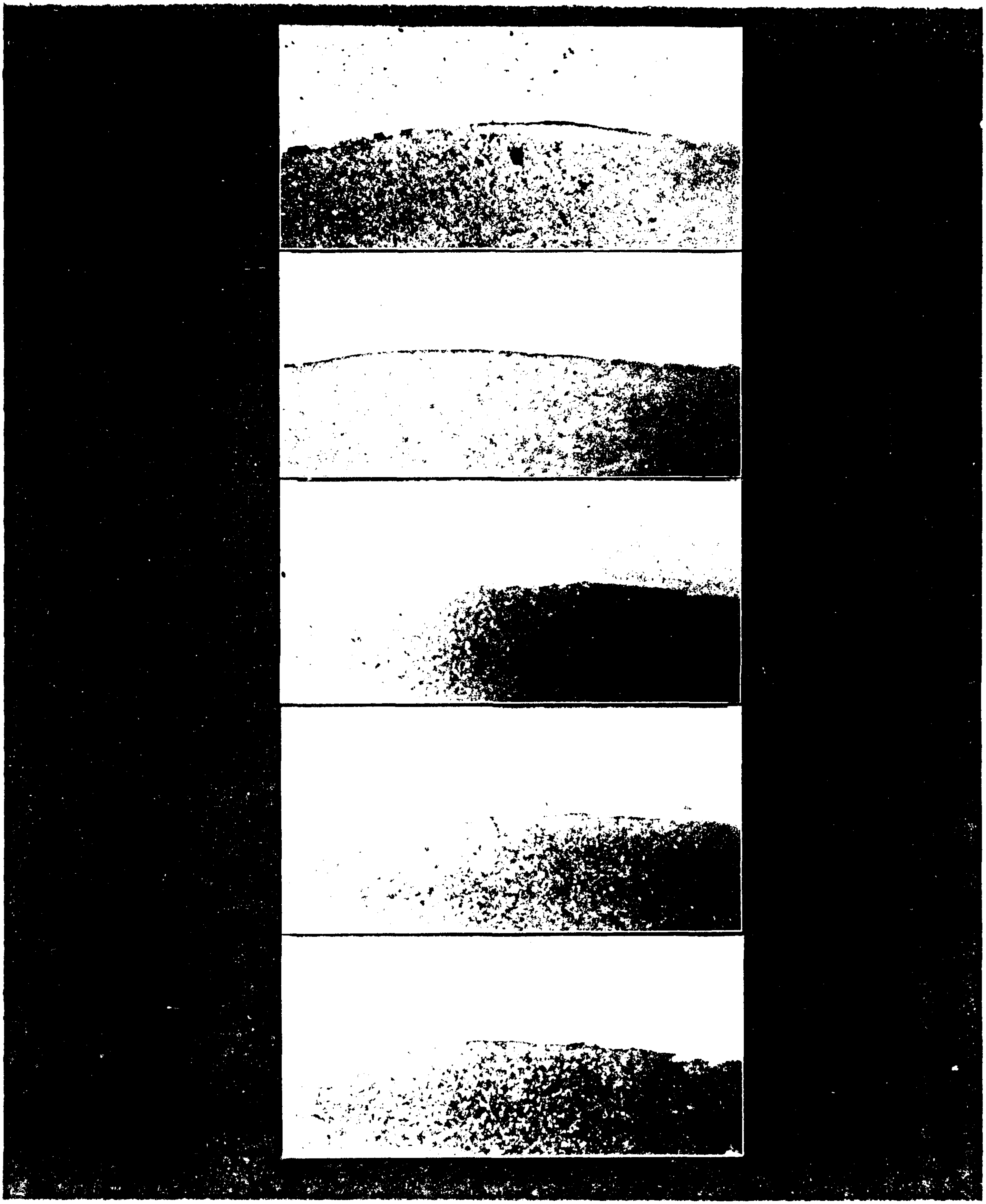


PLATE 10

FRONTAL VIEW

x40

WORST LINGUAL SURFACES

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

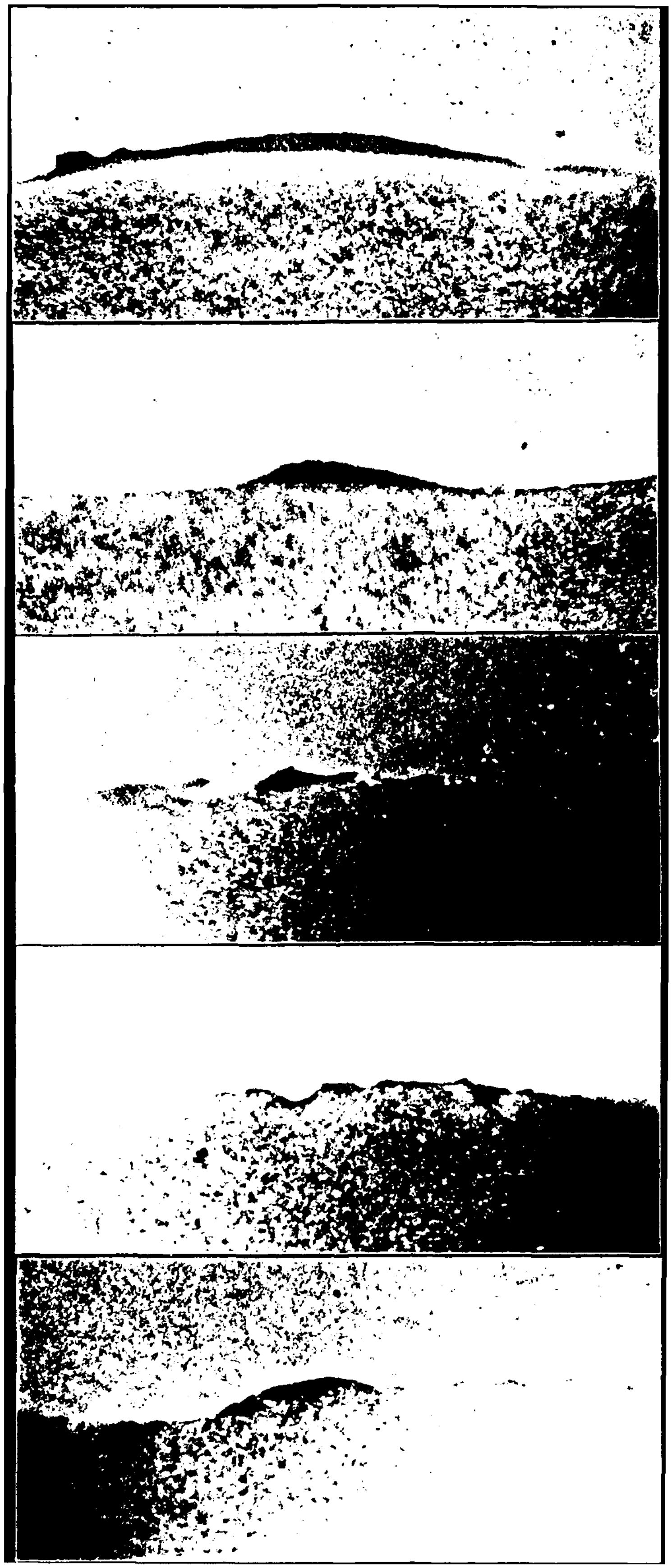


PLATE 11

FRONTAL VIEW

x40

BEST INTERPROXIMAL SURFACES

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

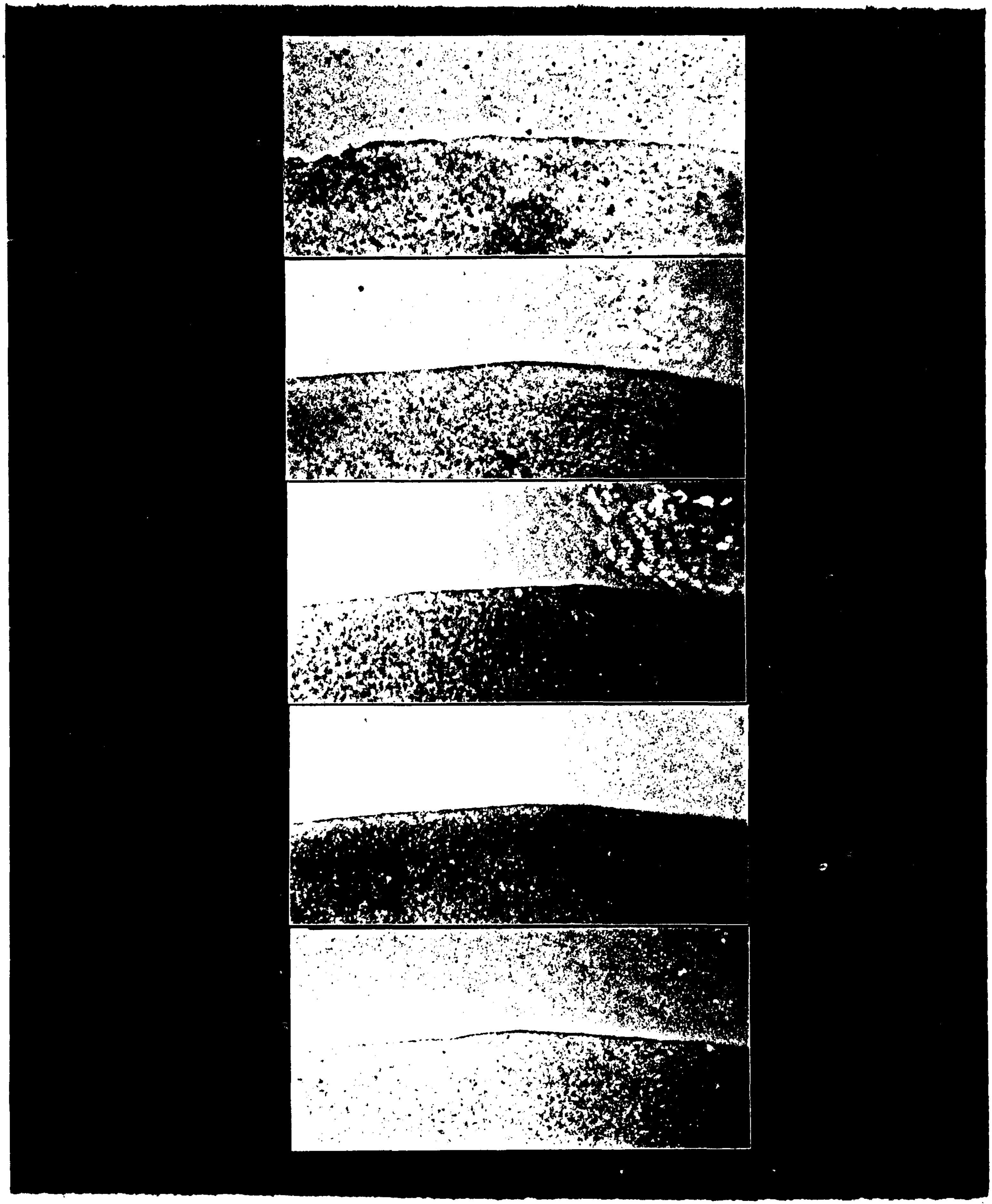


PLATE 12

FRONTAL VIEW

x40

WORST INTERPROXIMAL SURFACES

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

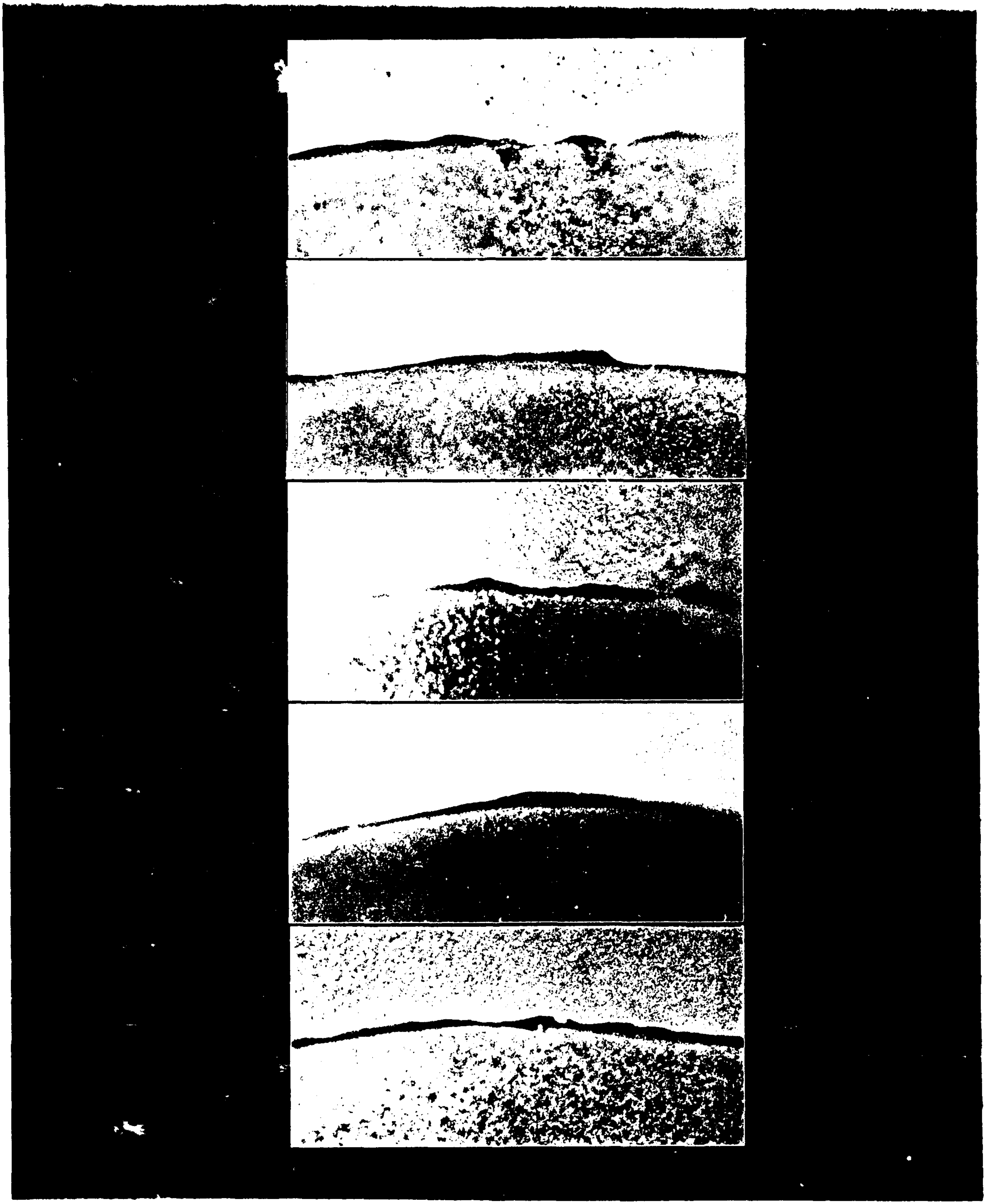


PLATE 13

CROSS-SECTIONAL VIEW

x40

BEST FACIAL SECTIONS

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

PLATE 15

CROSS-SECTIONAL VIEW

x40

BEST LINGUAL SECTIONS

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

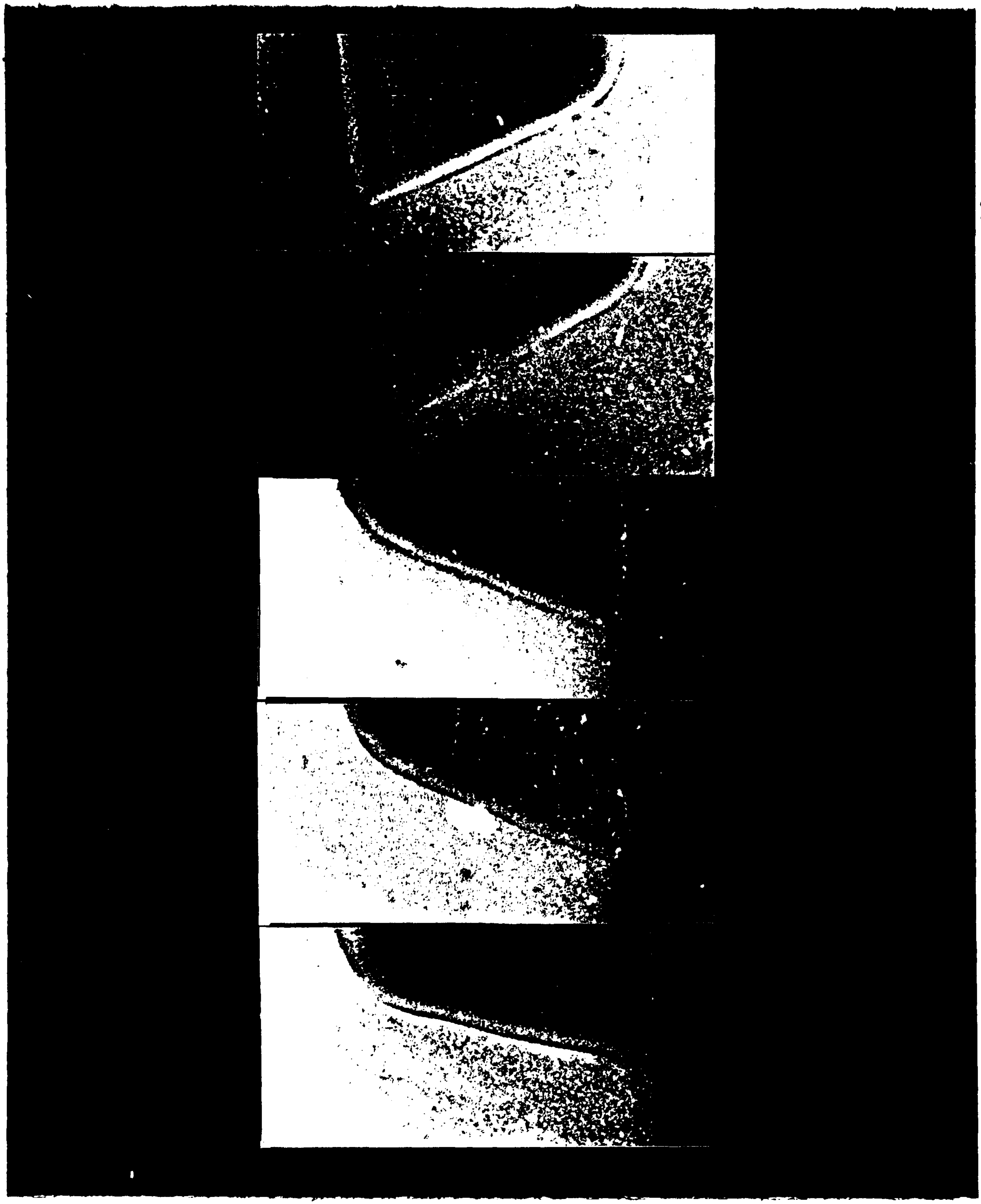


PLATE 16

CROSS-SECTIONAL VIEW

x40

WORST LINGUAL SECTIONS

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

PLATE 17

CROSS-SECTIONAL VIEW

x40

BEST INTERPROXIMAL SECTIONS

Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain

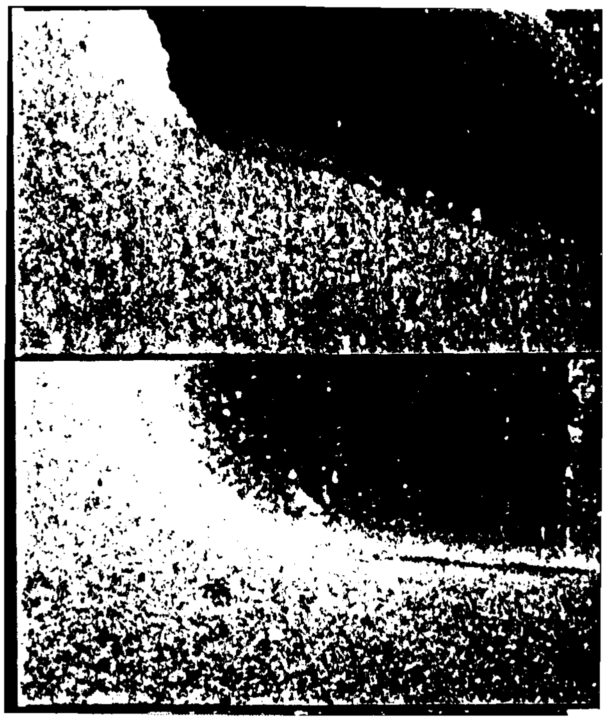


PLATE 18

CROSS-SECTIONAL VIEW

x40

WORST INTERPROXIMAL SECTIONS

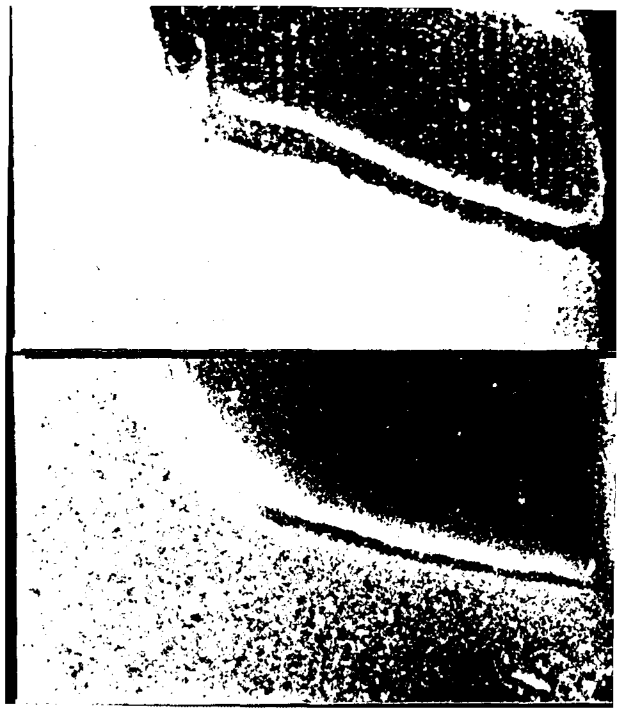
Dicor® Crown Control

Alternate Coping Design

Alternate Coping Design with Porcelain

Dicor® Plus Coping Design

Dicor® Plus Coping Design with Porcelain



APPENDIX

The following tables contain the raw data. Table 8 represents data for the frontal view. Table 9 represents data for the cross sectional view. Columns marked Value1 and Value2 are the actual values taken from the measuring drums on the measuring microscope. The column marked V1-V2 is the difference of Value1-Value2 in units of ten thousandths of an inch. The column marked μm converts the V1-V2 column to it's micrometer equivalent using the following formula: Micrometer Conversion = $\frac{(\text{Difference}/10000)}{.00003937}$. The remaining codes are as follows:

Group

1. Dicor® crown control.
2. Alternate coping without porcelain.
3. Alternate coping with porcelain.
4. Dicor® Plus coping without porcelain.
5. Dicor® Plus coping with porcelain.

Unit

A number, 1-8, representing the eight samples in each group.

Side

1. Facial surface.
2. Lingual surface.
3. Mesial surface.
4. Distal surface.

Point

A number, 1-5, representing the actual place of measurement on the specimen.

Table 8

Frontal View Raw Data

Group	Unit	Side	Point	Value1	Value2	V1-V2	μm
1	1	1	1	92.7	90.5	2.2	5.58801
1	1	1	2	91.9	89.5	2.4	6.09601
1	1	1	3	91.9	89	2.9	7.36601
1	1	1	4	91.8	90	1.8	4.57201
1	1	1	5	89.5	88.5	1	2.54001
1	1	2	1	90.9	88.7	2.2	5.58801
1	1	2	2	92.2	91.9	0.3	0.762
1	1	2	3	94.4	90.5	3.9	9.90602
1	1	2	4	95	91.7	3.3	8.38202
1	1	2	5	96	93.5	2.5	6.35001
1	1	3	1	13.7	7.8	5.9	14.98603
1	1	3	2	13	9.1	3.9	9.90602
1	1	3	3	13.5	8.8	4.7	11.93802
1	1	3	4	13.9	9.3	4.6	11.68402
1	1	3	5	16.2	11	5.2	13.20803
1	1	4	1	166.9	154	12.9	32.76607
1	1	4	2	167.6	155.3	12.3	31.24206
1	1	4	3	167.3	158.5	8.8	22.35204
1	1	4	4	167.8	159	8.8	22.35204
1	1	4	5	170.1	159.8	10.3	26.16205
1	2	1	1	131.8	129	2.8	7.11201
1	2	1	2	132.8	128	4.8	12.19202
1	2	1	3	133.8	124.5	9.3	23.62205
1	2	1	4	136.2	123.9	12.3	31.24206
1	2	1	5	135.5	129.5	6	15.24003
1	2	2	1	25.9	16.3	9.6	24.38405
1	2	2	2	23.3	16.3	7	17.78004

1	2	2	3	20	16	4	10.16002
1	2	2	4	20.9	16.2	4.7	11.93802
1	2	2	5	22.1	16.9	5.2	13.20803
1	2	3	1	257.2	238.5	18.7	47.49809
1	2	3	2	259.5	240.7	18.8	47.7521
1	2	3	3	246	241.5	4.5	11.43002
1	2	3	4	258.3	242	16.3	41.40208
1	2	3	5	246.1	240.9	5.2	13.20803
1	2	4	1	58.8	45.1	13.7	34.79807
1	2	4	2	58.2	46.8	11.4	28.95606
1	2	4	3	58.5	47.3	11.2	28.44806
1	2	4	4	57.5	49.5	8	20.32004
1	2	4	5	55.2	49.5	5.7	14.47803
1	3	1	1	21.5	14	7.5	19.05004
1	3	1	2	20.2	14.6	5.6	14.22403
1	3	1	3	18.5	15.2	3.3	8.38202
1	3	1	4	19.3	14.6	4.7	11.93802
1	3	1	5	18.5	14.5	4	10.16002
1	3	2	1	54.5	41	13.5	34.29007
1	3	2	2	55.1	42	13.1	33.27407
1	3	2	3	56.6	44	12.6	32.00406
1	3	2	4	57.1	43.2	13.9	35.30607
1	3	2	5	60.5	46.2	14.3	36.32207
1	3	3	1	144.5	138.7	5.8	14.73203
1	3	3	2	143.8	138.4	5.4	13.71603
1	3	3	3	143.8	134.2	9.6	24.38405
1	3	3	4	141.9	134.2	7.7	19.55804
1	3	3	5	142	134.9	7.1	18.03404
1	3	4	1	143.9	141.8	2.1	5.33401
1	3	4	2	143.8	140.5	3.3	8.38202
1	3	4	3	143.8	140	3.8	9.65202
1	3	4	4	142.9	141.5	1.4	3.55601
1	3	4	5	143.3	142.3	1	2.54001
1	4	1	1	127.8	110.9	16.9	42.92609
1	4	1	2	126.5	113.3	13.2	33.52807
1	4	1	3	128.1	114.9	13.2	33.52807
1	4	1	4	132.3	112.5	19.8	50.2921
1	4	1	5	133.7	108.5	25.2	64.00813
1	4	2	1	87.5	49.8	37.7	95.75819
1	4	2	2	85	51.2	33.8	85.85217
1	4	2	3	85.8	50.3	35.5	90.17018
1	4	2	4	90	46.5	43.5	110.4902

1	4	2	5	87.5	47	40.5	102.8702
1	4	3	1	43.5	6.2	37.3	94.74219
1	4	3	2	39.2	8	31.2	79.24816
1	4	3	3	37.8	7.9	29.9	75.94615
1	4	3	4	40.2	9.2	31	78.74016
1	4	3	5	41.2	6	35.2	89.40818
1	4	4	1	177.3	162.3	15	38.10008
1	4	4	2	177.2	164	13.2	33.52807
1	4	4	3	178.8	164.9	13.9	35.30607
1	4	4	4	179.2	167.2	12	30.48006
1	4	4	5	182.2	166.5	15.7	39.87808
1	5	1	1	204.5	197.8	6.7	17.01803
1	5	1	2	204.5	196.3	8.2	20.82804
1	5	1	3	203.6	194.7	8.9	22.60605
1	5	1	4	203	191.2	11.8	29.97206
1	5	1	5	203.5	196.5	7	17.78004
1	5	2	1	119	117.2	1.8	4.57201
1	5	2	2	123.5	118.9	4.6	11.68402
1	5	2	3	124.6	116.9	7.7	19.55804
1	5	2	4	125	114.4	10.6	26.92405
1	5	2	5	118.8	115.2	3.6	9.14402
1	5	3	1	121.7	113.8	7.9	20.06604
1	5	3	2	120.4	116	4.4	11.17602
1	5	3	3	120	116.9	3.1	7.87402
1	5	3	4	122.8	114.9	7.9	20.06604
1	5	3	5	124.3	117.8	6.5	16.51003
1	5	4	1	203.2	195	8.2	20.82804
1	5	4	2	198.5	191.8	6.7	17.01803
1	5	4	3	198.7	192.7	6	15.24003
1	5	4	4	203	196	7	17.78004
1	5	4	5	200.2	192.9	7.3	18.54204
1	6	1	1	132.6	120.3	12.3	31.24206
1	6	1	2	133.3	119.6	13.7	34.79807
1	6	1	3	135.2	119	16.2	41.14808
1	6	1	4	134.3	119.3	15	38.10008
1	6	1	5	135.8	120.3	15.5	39.37008
1	6	2	1	245.8	231	14.8	37.59208
1	6	2	2	244.7	229	15.7	39.87808
1	6	2	3	248.2	229.6	18.6	47.24409
1	6	2	4	249.7	233.5	16.2	41.14808
1	6	2	5	247.6	229.1	18.5	46.99009

1	6	3	1	201.4	172.3	29.1	73.91415
1	6	3	2	203.7	176.6	27.1	68.83414
1	6	3	3	204.8	175.9	28.9	73.40615
1	6	3	4	203.8	177.8	26	66.04013
1	6	3	5	204.7	178.8	25.9	65.78613
1	6	4	1	201.3	143.7	57.6	146.3043
1	6	4	2	197.3	143	54.3	137.9223
1	6	4	3	199.2	143.8	55.4	140.7163
1	6	4	4	196.1	142.5	53.6	136.1443
1	6	4	5	201.9	143.7	58.2	147.8283
1	7	1	1	184.4	170	14.4	36.57607
1	7	1	2	182.8	172	10.8	27.43205
1	7	1	3	185.3	169.8	15.5	39.37008
1	7	1	4	187.2	171.3	15.9	40.38608
1	7	1	5	188.2	170.3	17.9	45.46609
1	7	2	1	181.8	161	20.8	52.83211
1	7	2	2	183.2	159.7	23.5	59.69012
1	7	2	3	182.3	157.3	25	63.50013
1	7	2	4	186.6	156.5	30.1	76.45415
1	7	2	5	191	157.7	33.3	84.58217
1	7	3	1	235	211.8	23.2	58.92812
1	7	3	2	232.3	213.8	18.5	46.99009
1	7	3	3	232.3	214.6	17.7	44.95809
1	7	3	4	231.3	215	16.3	41.40208
1	7	3	5	231	215	16	40.64008
1	7	4	1	168.4	150.1	18.3	46.48209
1	7	4	2	167	147.3	19.7	50.0381
1	7	4	3	162.9	146.9	16	40.64008
1	7	4	4	159.3	149.9	9.4	23.87605
1	7	4	5	158.4	149	9.4	23.87605
1	8	1	1	87.2	70.5	16.7	42.41808
1	8	1	2	85.2	68.6	16.6	42.16408
1	8	1	3	82.7	71	11.7	29.71806
1	8	1	4	82.1	70.6	11.5	29.21006
1	8	1	5	81.2	71.9	9.3	23.62205
1	8	2	1	230.6	214.1	16.5	41.91008
1	8	2	2	228.7	214.3	14.4	36.57607
1	8	2	3	228	215.1	12.9	32.76607
1	8	2	4	227.9	214.8	13.1	33.27407
1	8	2	5	227.3	215	12.3	31.24206
1	8	3	1	220.4	210.6	9.8	24.89205
1	8	3	2	219	210.7	8.3	21.08204

1	8	3	3	218.9	209.5	9.4	23.87605
1	8	3	4	218.8	209.8	9	22.86005
1	8	3	5	219	208.9	10.1	25.65405
1	8	4	1	152	137.5	14.5	36.83007
1	8	4	2	150.3	136.5	13.8	35.05207
1	8	4	3	150.6	137.4	13.2	33.52807
1	8	4	4	150.3	136.8	13.5	34.29007
1	8	4	5	151.9	136.4	15.5	39.37008
2	1	1	1	147.2	130	17.2	43.68809
2	1	1	2	146.3	129.5	16.8	42.67209
2	1	1	3	145.5	132.3	13.2	33.52807
2	1	1	4	146	133.2	12.8	32.51207
2	1	1	5	143.8	132.5	11.3	28.70206
2	1	2	1	224.8	200	24.8	62.99213
2	1	2	2	226.7	200.5	26.2	66.54813
2	1	2	3	228	199.5	28.5	72.39014
2	1	2	4	229.8	201.5	28.3	71.88214
2	1	2	5	227.8	205	22.8	57.91212
2	1	3	1	74.8	70.2	4.6	11.68402
2	1	3	2	74.3	74	0.3	0.762
2	1	3	3	85.5	74	11.5	29.21006
2	1	3	4	84	78	6	15.24003
2	1	3	5	82.3	75.5	6.8	17.27203
2	1	4	1	63	54.6	8.4	21.33604
2	1	4	2	64	55	9	22.86005
2	1	4	3	66	54.2	11.8	29.97206
2	1	4	4	67.6	55.7	11.9	30.22606
2	1	4	5	67	54	13	33.02007
2	2	1	1	49.9	44	5.9	14.98603
2	2	1	2	49.9	42	7.9	20.06604
2	2	1	3	52.8	44.7	8.1	20.57404
2	2	1	4	49.3	41.6	7.7	19.55804
2	2	1	5	49.3	44.3	5	12.70003
2	2	2	1	163.6	156.2	7.4	18.79604
2	2	2	2	163.8	155	8.8	22.35204
2	2	2	3	161.3	151.5	9.8	24.89205
2	2	2	4	159.3	151.2	8.1	20.57404
2	2	2	5	158.5	156.5	2	5.08001
2	2	3	1	170	169	1	2.54001
2	2	3	2	167.9	166.8	1.1	2.79401
2	2	3	3	170	166.8	3.2	8.12802
2	2	3	4	170.5	166.3	4.2	10.66802

2	2	3	5	169.8	167.5	2.3	5.84201
2	2	4	1	42.8	37.3	5.5	13.97003
2	2	4	2	42.9	38.8	4.1	10.41402
2	2	4	3	44.2	39.6	4.6	11.68402
2	2	4	4	45.9	39.8	6.1	15.49403
2	2	4	5	42.5	37.8	4.7	11.93802
2	3	1	1	39.5	29.2	10.3	26.16205
2	3	1	2	38.2	30	8.2	20.82804
2	3	1	3	37.3	31.3	6	15.24003
2	3	1	4	37.8	31.9	5.9	14.98603
2	3	1	5	32.9	31.7	1.2	3.04801
2	3	2	1	116.7	111.8	4.9	12.44602
2	3	2	2	117.8	112.2	5.6	14.22403
2	3	2	3	117.5	113.9	3.6	9.14402
2	3	2	4	120.2	115	5.2	13.20803
2	3	2	5	121.1	112.2	8.9	22.60605
2	3	3	1	12.8	1.8	11	27.94006
2	3	3	2	11.2	-0.2	11.4	28.95606
2	3	3	3	14.5	1	13.5	34.29007
2	3	3	4	12.8	3.5	9.3	23.62205
2	3	3	5	12	-0.5	12.5	31.75006
2	3	4	1	225.3	217.8	7.5	19.05004
2	3	4	2	225	218.5	6.5	16.51003
2	3	4	3	225.3	216.5	8.8	22.35204
2	3	4	4	225.9	217.9	8	20.32004
2	3	4	5	225.5	220.9	4.6	11.68402
2	4	1	1	52.5	39.5	13	33.02007
2	4	1	2	50	39	11	27.94006
2	4	1	3	49.9	41	8.9	22.60605
2	4	1	4	49.9	39.1	10.8	27.43205
2	4	1	5	50.2	39.8	10.4	26.41605
2	4	2	1	80.6	61.6	19	48.2601
2	4	2	2	80.8	70.4	10.4	26.41605
2	4	2	3	79.9	67.8	12.1	30.73406
2	4	2	4	79.5	70.2	9.3	23.62205
2	4	2	5	80.2	73.3	6.9	17.52604
2	4	3	1	115.3	99.2	16.1	40.89408
2	4	3	2	113.1	99.7	13.4	34.03607
2	4	3	3	114.8	100.1	14.7	37.33807
2	4	3	4	118.8	108.5	10.3	26.16205
2	4	3	5	116	113.9	2.1	5.33401

2	4	4	1	196.1	170.5	25.6	65.02413
2	4	4	2	195.5	168	27.5	69.85014
2	4	4	3	195.1	169.2	25.9	65.78613
2	4	4	4	196.2	169.7	26.5	67.31013
2	4	4	5	196.3	171.5	24.8	62.99213
2	5	1	1	195.6	177.9	17.7	44.95809
2	5	1	2	195.6	178.2	17.4	44.19609
2	5	1	3	195.3	177.5	17.8	45.21209
2	5	1	4	195	175.9	19.1	48.5141
2	5	1	5	194.8	177.3	17.5	44.45009
2	5	2	1	83.7	74.9	8.8	22.35204
2	5	2	2	81.2	73.3	7.9	20.06604
2	5	2	3	80.2	74.3	5.9	14.98603
2	5	2	4	80.3	75.9	4.4	11.17602
2	5	2	5	80.5	74.8	5.7	14.47803
2	5	3	1	85.6	80	5.6	14.22403
2	5	3	2	83.6	79.9	3.7	9.39802
2	5	3	3	83.9	80	3.9	9.90602
2	5	3	4	84.5	81.3	3.2	8.12802
2	5	3	5	84.8	82	2.8	7.11201
2	5	4	1	90.2	73.8	16.4	41.65608
2	5	4	2	87.4	74.3	13.1	33.27407
2	5	4	3	87.4	72.3	15.1	38.35408
2	5	4	4	87.6	73.9	13.7	34.79807
2	5	4	5	87	75	12	30.48006
2	6	1	1	100.7	73.3	27.4	69.59614
2	6	1	2	101.2	72	29.2	74.16815
2	6	1	3	100.8	69.5	31.3	79.50216
2	6	1	4	100.2	70	30.2	76.70815
2	6	1	5	104.9	71.5	33.4	84.83617
2	6	2	1	65.7	46.3	19.4	49.2761
2	6	2	2	65	48.2	16.8	42.67209
2	6	2	3	64.3	47.2	17.1	43.43409
2	6	2	4	64.8	51	13.8	35.05207
2	6	2	5	64	50.7	13.3	33.78207
2	6	3	1	165.3	123.7	41.6	105.6642
2	6	3	2	192.5	128.2	64.3	163.3223
2	6	3	3	184.5	129.5	55	139.7003
2	6	3	4	189.2	127.5	61.7	156.7183
2	6	3	5	194.2	127.2	67	170.1803
2	6	4	1	46.7	22.4	24.3	61.72212
2	6	4	2	45.7	22.3	23.4	59.43612

2	6	4	3	42.3	23	19.3	49.0221
2	6	4	4	42.8	21.1	21.7	55.11811
2	6	4	5	45.1	22.1	23	58.42012
2	7	1	1	223	194.9	28.1	71.37414
2	7	1	2	221.8	196.1	25.7	65.27813
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2	7	2	2	41.4	28.7	12.7	32.25806
2	7	2	3	41.5	28.3	13.2	33.52807
2	7	2	4	40.3	27.3	13	33.02007
2	7	2	5	39.6	26.5	13.1	33.27407
2	7	3	1	43.2	16.4	26.8	68.07214
2	7	3	2	40.4	14.6	25.8	65.53213
2	7	3	3	41.2	17.8	23.4	59.43612
2	7	3	4	38.6	17.3	21.3	54.10211
2	7	3	5	36.4	16.9	19.5	49.5301
2	7	4	1	230.6	214.3	16.3	41.40208
2	7	4	2	230.5	214.1	16.4	41.65608
2	7	4	3	230.2	214.3	15.9	40.38608
2	7	4	4	230.6	215.7	14.9	37.84608
2	7	4	5	231.8	216.4	15.4	39.11608
2	8	1	1	179.3	166.7	12.6	32.00406
2	8	1	2	178.8	167.9	10.9	27.68606
2	8	1	3	179.4	167.9	11.5	29.21006
2	8	1	4	180.5	167.2	13.3	33.78207
2	8	1	5	181.4	166.4	15	38.10008
2	8	2	1	181.5	166.3	15.2	38.60808
2	8	2	2	182.1	167.1	15	38.10008
2	8	2	3	183.8	167.5	16.3	41.40208
2	8	2	4	184	163	21	53.34011
2	8	2	5	184.1	164.1	20	50.8001
2	8	3	1	225.3	202.3	23	58.42012
2	8	3	2	224.1	203	21.1	53.59411
2	8	3	3	221.6	203.5	18.1	45.97409
2	8	3	4	221.4	201.7	19.7	50.0381
2	8	3	5	219.8	200.7	19.1	48.5141
2	8	4	1	67.3	45.4	21.9	55.62611
2	8	4	2	65.7	45.2	20.5	52.0701
2	8	4	3	65.9	45	20.9	53.08611
2	8	4	4	65.2	44.3	20.9	53.08611

2	8	4	5	64	46.2	17.8	45.21209
3	1	1	1	57.5	42.9	14.6	37.08407
3	1	1	2	57	40.5	16.5	41.91008
3	1	1	3	53.9	39.5	14.4	36.57607
3	1	1	4	52	41.2	10.8	27.43205
3	1	1	5	53.2	42	11.2	28.44806
3	1	2	1	71.9	62	9.9	25.14605
3	1	2	2	70.8	63.5	7.3	18.54204
3	1	2	3	74.5	64.5	10	25.40005
3	1	2	4	71.3	63.5	7.8	19.81204
3	1	2	5	72.1	63	9.1	23.11405
3	1	3	1	130.7	107.9	22.8	57.91212
3	1	3	2	127.8	108.5	19.3	49.0221
3	1	3	3	121.5	107.5	14	35.56007
3	1	3	4	118	110.5	7.5	19.05004
3	1	3	5	117	108.3	8.7	22.09804
3	1	4	1	124.3	102.5	21.8	55.37211
3	1	4	2	122.5	104	18.5	46.99009
3	1	4	3	122	102.2	19.8	50.2921
3	1	4	4	122.3	105	17.3	43.94209
3	1	4	5	125	105.9	19.1	48.5141
3	2	1	1	129.4	112.4	17	43.18009
3	2	1	2	130	114	16	40.64008
3	2	1	3	131.2	115.5	15.7	39.87808
3	2	1	4	130.5	115.2	15.3	38.86208
3	2	1	5	130	115.8	14.2	36.06807
3	2	2	1	39.3	39	0.3	0.762
3	2	2	2	42.3	37.5	4.8	12.19202
3	2	2	3	43.3	37.2	6.1	15.49403
3	2	2	4	44.5	39	5.5	13.97003
3	2	2	5	45.2	38.8	6.4	16.25603
3	2	3	1	135.7	125.3	10.4	26.41605
3	2	3	2	137	129.1	7.9	20.06604
3	2	3	3	133.2	129.2	4	10.16002
3	2	3	4	135.8	129.5	6.3	16.00203
3	2	3	5	137	128.2	8.8	22.35204
3	2	4	1	187.2	178.9	8.3	21.08204
3	2	4	2	186.3	179.2	7.1	18.03404
3	2	4	3	186	178.8	7.2	18.28804
3	2	4	4	187	180.5	6.5	16.51003
3	2	4	5	187.6	181.3	6.3	16.00203

3	3	1	1	163.9	153.8	10.1	25.65405
3	3	1	2	166.3	150.3	16	40.64008
3	3	1	3	165.9	153	12.9	32.76607
3	3	1	4	166.7	153.8	12.9	32.76607
3	3	1	5	168.3	154.8	13.5	34.29007
3	3	2	1	142	135.9	6.1	15.49403
3	3	2	2	140.5	134.2	6.3	16.00203
3	3	2	3	139.3	134.3	5	12.70003
3	3	2	4	141.2	134.3	6.9	17.52604
3	3	2	5	142.5	134	8.5	21.59004
3	3	3	1	212	205	7	17.78004
3	3	3	2	211.3	205.6	5.7	14.47803
3	3	3	3	211.6	205.4	6.2	15.74803
3	3	3	4	212.1	205.6	6.5	16.51003
3	3	3	5	212.6	206.3	6.3	16.00203
3	3	4	1	61.2	49	12.2	30.98806
3	3	4	2	57.8	48.9	8.9	22.60605
3	3	4	3	60.2	47	13.2	33.52807
3	3	4	4	60	46.2	13.8	35.05207
3	3	4	5	61.5	48.8	12.7	32.25806
3	4	1	1	206.5	184.5	22	55.88011
3	4	1	2	207.1	180.2	26.9	68.32614
3	4	1	3	205.3	184.8	20.5	52.0701
3	4	1	4	206.2	184	22.2	56.38811
3	4	1	5	206.5	183.5	23	58.42012
3	4	2	1	115	101.8	13.2	33.52807
3	4	2	2	108.4	102.1	6.3	16.00203
3	4	2	3	114.8	103.2	11.6	29.46406
3	4	2	4	114.5	102.5	12	30.48006
3	4	2	5	115	104.2	10.8	27.43205
3	4	3	1	235.7	220.2	15.5	39.37008
3	4	3	2	237	222.9	14.1	35.81407
3	4	3	3	241.5	224.9	16.6	42.16408
3	4	3	4	241.7	222.5	19.2	48.7681
3	4	3	5	239.5	223.8	15.7	39.87808
3	4	4	1	207.8	184.6	23.2	58.92812
3	4	4	2	208.1	185.9	22.2	56.38811
3	4	4	3	208	184.9	23.1	58.67412
3	4	4	4	208.3	183.8	24.5	62.23012
3	4	4	5	208.5	185.7	22.8	57.91212
3	5	1	1	89	72.4	16.6	42.16408
3	5	1	2	86.8	71.8	15	38.10008

3	5	1	3	87.9	70.9	17	43.18009
3	5	1	4	87.4	70.3	17.1	43.43409
3	5	1	5	91.4	71.2	20.2	51.3081
3	5	2	1	118.3	101	17.3	43.94209
3	5	2	2	116.7	100.5	16.2	41.14808
3	5	2	3	117.2	103	14.2	36.06807
3	5	2	4	116.8	102	14.8	37.59208
3	5	2	5	121	103.8	17.2	43.68809
3	5	3	1	216.2	200.2	16	40.64008
3	5	3	2	215.8	197.6	18.2	46.22809
3	5	3	3	215.8	198.5	17.3	43.94209
3	5	3	4	222.9	198.2	24.7	62.73813
3	5	3	5	229.5	199.4	30.1	76.45415
3	5	4	1	65	43	22	55.88011
3	5	4	2	66.9	41.3	25.6	65.02413
3	5	4	3	66.8	41.3	25.5	64.77013
3	5	4	4	64.2	42.3	21.9	55.62611
3	5	4	5	62	46.3	15.7	39.87808
3	6	1	1	121.7	104.2	17.5	44.45009
3	6	1	2	124.6	105.2	19.4	49.2761
3	6	1	3	125.2	105.8	19.4	49.2761
3	6	1	4	125.6	105.7	19.9	50.5461
3	6	1	5	124.8	106.4	18.4	46.73609
3	6	2	1	23.8	15.8	8	20.32004
3	6	2	2	27.2	17.3	9.9	25.14605
3	6	2	3	26.2	13.5	12.7	32.25806
3	6	2	4	23.4	13.8	9.6	24.38405
3	6	2	5	24.8	13.8	11	27.94006
3	6	3	1	73.3	56.6	16.7	42.41808
3	6	3	2	72	55	17	43.18009
3	6	3	3	73.3	56.9	16.4	41.65608
3	6	3	4	73.6	58.9	14.7	37.33807
3	6	3	5	75.5	55.4	20.1	51.0541
3	6	4	1	229.3	214.8	14.5	36.83007
3	6	4	2	225.8	204.4	21.4	54.35611
3	6	4	3	226.8	204	22.8	57.91212
3	6	4	4	229.5	216.8	12.7	32.25806
3	6	4	5	228.9	219.4	9.5	24.13005
3	7	1	1	115.9	84.7	31.2	79.24816
3	7	1	2	111.8	86.3	25.5	64.77013
3	7	1	3	45.4	18	27.4	69.59614
3	7	1	4	45.3	17.2	28.1	71.37414

3	7	1	5	46.1	16.9	29.2	74.16815
3	7	2	1	234.3	220	14.3	36.32207
3	7	2	2	234	221.1	12.9	32.76607
3	7	2	3	234.6	220.5	14.1	35.81407
3	7	2	4	235.3	223	12.3	31.24206
3	7	2	5	235.2	229.9	5.3	13.46203
3	7	3	1	184.3	171.1	13.2	33.52807
3	7	3	2	183.2	174.5	8.7	22.09804
3	7	3	3	182.3	175.3	7	17.78004
3	7	3	4	181.2	176.6	4.6	11.68402
3	7	3	5	182	175	7	17.78004
3	7	4	1	52.6	42.7	9.9	25.14605
3	7	4	2	52.3	43.3	9	22.86005
3	7	4	3	53.2	43.8	9.4	23.87605
3	7	4	4	53.2	45.4	7.8	19.81204
3	7	4	5	52.5	45.3	7.2	18.28804
3	8	1	1	95.5	83.9	11.6	29.46406
3	8	1	2	95.6	84.2	11.4	28.95606
3	8	1	3	97.7	82.3	15.4	39.11608
3	8	1	4	98.8	83.4	15.4	39.11608
3	8	1	5	98	84.2	13.8	35.05207
3	8	2	1	159.5	146.8	12.7	32.25806
3	8	2	2	158.7	148.7	10	25.40005
3	8	2	3	158.7	148.4	10.3	26.16205
3	8	2	4	160.8	148.6	12.2	30.98806
3	8	2	5	159.5	148.3	11.2	28.44806
3	8	3	1	102.3	90.2	12.1	30.73406
3	8	3	2	101.3	91	10.3	26.16205
3	8	3	3	104.6	94.2	10.4	26.41605
3	8	3	4	116.8	93.3	23.5	59.69012
3	8	3	5	109.6	94.2	15.4	39.11608
3	8	4	1	134	114.2	19.8	50.2921
3	8	4	2	122.5	102.5	20	50.8001
3	8	4	3	129.5	112	17.5	44.45009
3	8	4	4	121.5	113.2	8.3	21.08204
3	8	4	5	126.7	113.3	13.4	34.03607
4	1	1	1	87.5	81.5	6	15.24003
4	1	1	2	90.2	81.9	8.3	21.08204
4	1	1	3	88.5	83	5.5	13.97003
4	1	1	4	87.8	82.8	5	12.70003
4	1	1	5	90.2	83.4	6.8	17.27203

4	1	2	1	32.2	8.3	23.9	60.70612
4	1	2	2	29	13	16	40.64008
4	1	2	3	35.3	11	24.3	61.72212
4	1	2	4	31.3	11	20.3	51.5621
4	1	2	5	32	10.9	21.1	53.59411
4	1	3	1	149.3	144.5	4.8	12.19202
4	1	3	2	150.3	143	7.3	18.54204
4	1	3	3	149.6	145.3	4.3	10.92202
4	1	3	4	152.2	141.2	11	27.94006
4	1	3	5	152.3	144.2	8.1	20.57404
4	1	4	1	74.2	69.8	4.4	11.17602
4	1	4	2	73.8	71.9	1.9	4.82601
4	1	4	3	73.1	71	2.1	5.33401
4	1	4	4	74.5	71.9	2.6	6.60401
4	1	4	5	73.8	70.5	3.3	8.38202
4	2	1	1	62.2	44.5	17.7	44.95809
4	2	1	2	62.7	47.1	15.6	39.62408
4	2	1	3	63.3	47	16.3	41.40208
4	2	1	4	61.8	45.8	16	40.64008
4	2	1	5	63.8	45.4	18.4	46.73609
4	2	2	1	208.8	206	2.8	7.11201
4	2	2	2	212.7	210.5	2.2	5.58801
4	2	2	3	214.5	206.7	7.8	19.81204
4	2	2	4	215.1	207	8.1	20.57404
4	2	2	5	213.5	208.2	5.3	13.46203
4	2	3	1	47.8	41.9	5.9	14.98603
4	2	3	2	49	43.3	5.7	14.47803
4	2	3	3	49.2	44.2	5	12.70003
4	2	3	4	50	44.3	5.7	14.47803
4	2	3	5	50.3	42.9	7.4	18.79604
4	2	4	1	232.5	226.5	6	15.24003
4	2	4	2	234.2	227.5	6.7	17.01803
4	2	4	3	238.2	225.5	12.7	32.25806
4	2	4	4	236	227.5	8.5	21.59004
4	2	4	5	238.9	229	9.9	25.14605
4	3	1	1	139	124.3	14.7	37.33807
4	3	1	2	139.1	123.2	15.9	40.38608
4	3	1	3	139.5	125.8	13.7	34.79807
4	3	1	4	137.8	126.8	11	27.94006
4	3	1	5	140.5	127	13.5	34.29007
4	3	2	1	146.7	110.5	36.2	91.94818
4	3	2	2	141.8	109.8	32	81.28016

4	3	2	3	142.5	108.3	34.2	86.86817
4	3	2	4	141.3	106.5	34.8	88.39218
4	3	2	5	139.6	109	30.6	77.72416
4	3	3	1	80.6	71.2	9.4	23.87605
4	3	3	2	77.3	69.2	8.1	20.57404
4	3	3	3	78	70	8	20.32004
4	3	3	4	79.8	71.2	8.6	21.84404
4	3	3	5	82.7	72.5	10.2	25.90805
4	3	4	1	69.5	59.3	10.2	25.90805
4	3	4	2	69.9	61.3	8.6	21.84404
4	3	4	3	68.5	57.5	11	27.94006
4	3	4	4	66.8	60.5	6.3	16.00203
4	3	4	5	68.5	60.7	7.8	19.81204
4	4	1	1	224.7	214.3	10.4	26.41605
4	4	1	2	224.5	215.9	8.6	21.84404
4	4	1	3	223.6	216.1	7.5	19.05004
4	4	1	4	224.3	213.1	11.2	28.44806
4	4	1	5	225.2	215.8	9.4	23.87605
4	4	2	1	212.3	206.8	5.5	13.97003
4	4	2	2	211.3	205.9	5.4	13.71603
4	4	2	3	210.9	206.9	4	10.16002
4	4	2	4	212	205.6	6.4	16.25603
4	4	2	5	212.3	205.3	7	17.78004
4	4	3	1	131	126	5	12.70003
4	4	3	2	132.3	129.5	2.8	7.11201
4	4	3	3	131.5	129.3	2.2	5.58801
4	4	3	4	132.2	129.5	2.7	6.85801
4	4	3	5	133.8	130.2	3.6	9.14402
4	4	4	1	161.8	152.5	9.3	23.62205
4	4	4	2	159.5	150.3	9.2	23.36805
4	4	4	3	159.3	151.3	8	20.32004
4	4	4	4	157.8	151.8	6	15.24003
4	4	4	5	157.8	151.3	6.5	16.51003
4	5	1	1	121.4	110	11.4	28.95606
4	5	1	2	126.8	110.3	16.5	41.91008
4	5	1	3	130.6	110.2	20.4	51.8161
4	5	1	4	128.8	110.3	18.5	46.99009
4	5	1	5	128.3	111.2	17.1	43.43409
4	5	2	1	167.2	158	9.2	23.36805
4	5	2	2	165.3	155.8	9.5	24.13005
4	5	2	3	165.3	157.1	8.2	20.82804
4	5	2	4	164.2	156.5	7.7	19.55804

4	5	2	5	164.5	155.9	8.6	21.84404
4	5	3	1	219.4	189.6	29.8	75.69215
4	5	3	2	215.8	183.6	32.2	81.78816
4	5	3	3	219.6	186	33.6	85.34417
4	5	3	4	217.5	186.6	30.9	78.48616
4	5	3	5	218.4	185.1	33.3	84.58217
4	5	4	1	137.5	121.3	16.2	41.14808
4	5	4	2	136	120.2	15.8	40.13208
4	5	4	3	138.2	118.1	20.1	51.0541
4	5	4	4	136.1	118.2	17.9	45.46609
4	5	4	5	137.2	118.1	19.1	48.5141
4	6	1	1	124	112.5	11.5	29.21006
4	6	1	2	122.7	115.3	7.4	18.79604
4	6	1	3	125.8	113.9	11.9	30.22606
4	6	1	4	122.2	113.7	8.5	21.59004
4	6	1	5	123.2	113.8	9.4	23.87605
4	6	2	1	144.8	135	9.8	24.89205
4	6	2	2	145.3	134.5	10.8	27.43205
4	6	2	3	145	133.8	11.2	28.44806
4	6	2	4	145.9	133.2	12.7	32.25806
4	6	2	5	146	134.4	11.6	29.46406
4	6	3	1	28.8	17.7	11.1	28.19406
4	6	3	2	28.9	19.3	9.6	24.38405
4	6	3	3	30.2	17.8	12.4	31.49606
4	6	3	4	28.2	18.2	10	25.40005
4	6	3	5	28.3	18	10.3	26.16205
4	6	4	1	167.8	150.8	17	43.18009
4	6	4	2	166.3	151.1	15.2	38.60808
4	6	4	3	165.5	150.8	14.7	37.33807
4	6	4	4	165.5	151.8	13.7	34.79807
4	6	4	5	164.8	151.3	13.5	34.29007
4	7	1	1	203.6	181	22.6	57.40411
4	7	1	2	201.3	184.7	16.6	42.16408
4	7	1	3	203.2	185.7	17.5	44.45009
4	7	1	4	201.3	185.3	16	40.64008
4	7	1	5	202.3	186	16.3	41.40208
4	7	2	1	181.2	168.8	12.4	31.49606
4	7	2	2	186.3	168.8	17.5	44.45009
4	7	2	3	185	171.3	13.7	34.79807
4	7	2	4	185.3	171.8	13.5	34.29007
4	7	2	5	184.8	171.3	13.5	34.29007

4	7	3	1	248.6	232.8	15.8	40.13208
4	7	3	2	247.8	232.3	15.5	39.37008
4	7	3	3	245.4	231	14.4	36.57607
4	7	3	4	245.6	233.6	12	30.48006
4	7	3	5	244.6	232.7	11.9	30.22606
4	7	4	1	258.5	232	26.5	67.31013
4	7	4	2	260.9	238.6	22.3	56.64211
4	7	4	3	260.5	235.7	24.8	62.99213
4	7	4	4	261.2	238.7	22.5	57.15011
4	7	4	5	260	232.8	27.2	69.08814
4	8	1	1	235.7	215	20.7	52.57811
4	8	1	2	235.6	212.6	23	58.42012
4	8	1	3	237.2	214.6	22.6	57.40411
4	8	1	4	237.6	216.3	21.3	54.10211
4	8	1	5	237.7	216.3	21.4	54.35611
4	8	2	1	114.6	88.2	26.4	67.05613
4	8	2	2	115.2	87.9	27.3	69.34214
4	8	2	3	113.2	87.8	25.4	64.51613
4	8	2	4	113	88.4	24.6	62.48412
4	8	2	5	113.7	86.5	27.2	69.08814
4	8	3	1	41.5	33.2	8.3	21.08204
4	8	3	2	40.7	34.1	6.6	16.76403
4	8	3	3	38.2	34	4.2	10.66802
4	8	3	4	39.1	33.9	5.2	13.20803
4	8	3	5	38.6	34	4.6	11.68402
4	8	4	1	70	46.1	23.9	60.70612
4	8	4	2	74.1	53	21.1	53.59411
4	8	4	3	71.2	44.6	26.6	67.56414
4	8	4	4	68.8	48.3	20.5	52.0701
4	8	4	5	68	47.5	20.5	52.0701
5	1	1	1	207.8	192	15.8	40.13208
5	1	1	2	205.7	194.2	11.5	29.21006
5	1	1	3	211	195.2	15.8	40.13208
5	1	1	4	208.1	193.5	14.6	37.08407
5	1	1	5	210.2	195.2	15	38.10008
5	1	2	1	236.2	213	23.2	58.92812
5	1	2	2	236.3	215.2	21.1	53.59411
5	1	2	3	235.5	217.5	18	45.72009
5	1	2	4	233.2	216.5	16.7	42.41808
5	1	2	5	231.5	212.5	19	48.2601
5	1	3	1	181.5	155.7	25.8	65.53213
5	1	3	2	183.7	155	28.7	72.89815

5	1	3	3	184.3	157.5	26.8	68.07214
5	1	3	4	186.9	157.7	29.2	74.16815
5	1	3	5	185	158.2	26.8	68.07214
5	1	4	1	10.8	4.1	6.7	17.01803
5	1	4	2	8.9	5.2	3.7	9.39802
5	1	4	3	10.9	5	5.9	14.98603
5	1	4	4	9.8	4.9	4.9	12.44602
5	1	4	5	10.2	3.5	6.7	17.01803
5	2	1	1	161.8	156	5.8	14.73203
5	2	1	2	0	0	0	0
5	2	1	3	0	0	0	0
5	2	1	4	0	0	0	0
5	2	1	5	160.5	157.3	3.2	8.12802
5	2	2	1	41.2	32.8	8.4	21.33604
5	2	2	2	43.1	34	9.1	23.11405
5	2	2	3	44.5	33.5	11	27.94006
5	2	2	4	44	35.2	8.8	22.35204
5	2	2	5	43.8	37.2	6.6	16.76403
5	2	3	1	224.6	221.5	3.1	7.87402
5	2	3	2	227.2	220.5	6.7	17.01803
5	2	3	3	225.5	219.3	6.2	15.74803
5	2	3	4	228.3	220.9	7.4	18.79604
5	2	3	5	230	220.5	9.5	24.13005
5	2	4	1	235.1	226	9.1	23.11405
5	2	4	2	238.2	234	4.2	10.66802
5	2	4	3	238.8	229.9	8.9	22.60605
5	2	4	4	239.5	231.2	8.3	21.08204
5	2	4	5	237.5	234.2	3.3	8.38202
5	3	1	1	91.5	77.6	13.9	35.30607
5	3	1	2	91	79.9	11.1	28.19406
5	3	1	3	93	77.8	15.2	38.60808
5	3	1	4	90.8	79	11.8	29.97206
5	3	1	5	90.9	81.5	9.4	23.87605
5	3	2	1	142.9	131	11.9	30.22606
5	3	2	2	142.7	130	12.7	32.25806
5	3	2	3	145.3	131.5	13.8	35.05207
5	3	2	4	144.7	133.5	11.2	28.44806
5	3	2	5	147.2	136.3	10.9	27.68606
5	3	3	1	81.5	75.7	5.8	14.73203
5	3	3	2	81.7	77.5	4.2	10.66802
5	3	3	3	81.3	75	6.3	16.00203
5	3	3	4	81.9	75.5	6.4	16.25603

5	3	3	5	83.7	72.6	11.1	28.19406
5	3	4	1	215.5	193.9	21.6	54.86411
5	3	4	2	213.2	193	20.2	51.3081
5	3	4	3	212.3	193.2	19.1	48.5141
5	3	4	4	212.2	194.5	17.7	44.95809
5	3	4	5	210	193	17	43.18009
5	4	1	1	219.2	202.8	16.4	41.65608
5	4	1	2	217.3	206.8	10.5	26.67005
5	4	1	3	215.9	203	12.9	32.76607
5	4	1	4	215.5	203.5	12	30.48006
5	4	1	5	217.3	203.2	14.1	35.81407
5	4	2	1	120.5	117.8	2.7	6.85801
5	4	2	2	121.5	119.3	2.2	5.58801
5	4	2	3	122.5	119.5	3	7.62002
5	4	2	4	123.3	120.2	3.1	7.87402
5	4	2	5	125	118.7	6.3	16.00203
5	4	3	1	190.8	187	3.8	9.65202
5	4	3	2	194.5	189.5	5	12.70003
5	4	3	3	193.1	191	2.1	5.33401
5	4	3	4	193.8	191	2.8	7.11201
5	4	3	5	194.3	190.2	4.1	10.41402
5	4	4	1	216.7	214.9	1.8	4.57201
5	4	4	2	217.3	215.2	2.1	5.33401
5	4	4	3	217.3	215.5	1.8	4.57201
5	4	4	4	216.9	214.3	2.6	6.60401
5	4	4	5	216.7	215.5	1.2	3.04801
5	5	1	1	232.3	201.3	31	78.74016
5	5	1	2	220	201.8	18.2	46.22809
5	5	1	3	219.6	199.8	19.8	50.2921
5	5	1	4	218.9	201	17.9	45.46609
5	5	1	5	218.5	200.5	18	45.72009
5	5	2	1	34.2	12.3	21.9	55.62611
5	5	2	2	34.9	13.8	21.1	53.59411
5	5	2	3	37.4	16	21.4	54.35611
5	5	2	4	35.5	17	18.5	46.99009
5	5	2	5	34.6	12.9	21.7	55.11811
5	5	3	1	71.3	63.5	7.8	19.81204
5	5	3	2	71.3	61.9	9.4	23.87605
5	5	3	3	73.8	63.5	10.3	26.16205
5	5	3	4	72.3	62.2	10.1	25.65405
5	5	3	5	73.8	64.5	9.3	23.62205

5	5	4	1	192.5	177.3	15.2	38.60808
5	5	4	2	192.2	178.9	13.3	33.78207
5	5	4	3	190.5	174.8	15.7	39.87808
5	5	4	4	189.6	175.6	14	35.56007
5	5	4	5	189.6	178	11.6	29.46406
5	6	1	1	174.3	161.2	13.1	33.27407
5	6	1	2	174.8	160.8	14	35.56007
5	6	1	3	175.3	159.7	15.6	39.62408
5	6	1	4	174.7	159.9	14.8	37.59208
5	6	1	5	174.3	159.6	14.7	37.33807
5	6	2	1	28.2	21	7.2	18.28804
5	6	2	2	30.8	19	11.8	29.97206
5	6	2	3	32	18.9	13.1	33.27407
5	6	2	4	31	19.2	11.8	29.97206
5	6	2	5	30.9	18.7	12.2	30.98806
5	6	3	1	59	45.5	13.5	34.29007
5	6	3	2	57.7	46.2	11.5	29.21006
5	6	3	3	58.3	46.7	11.6	29.46406
5	6	3	4	57.9	44	13.9	35.30607
5	6	3	5	57.9	47.8	10.1	25.65405
						0	0
5	6	4	1	202.8	193.2	9.6	24.38405
5	6	4	2	203.3	193.3	10	25.40005
5	6	4	3	205	192.3	12.7	32.25806
5	6	4	4	204.3	192.2	12.1	30.73406
5	6	4	5	202.8	192	10.8	27.43205
5	7	1	1	98.2	84.6	13.6	34.54407
5	7	1	2	96.6	86.2	10.4	26.41605
5	7	1	3	96	86.8	9.2	23.36805
5	7	1	4	96.6	88	8.6	21.84404
5	7	1	5	96.3	87.5	8.8	22.35204
5	7	2	1	28.8	0.3	28.5	72.39014
5	7	2	2	22.4	4.5	17.9	45.46609
5	7	2	3	27.2	4.8	22.4	56.89611
5	7	2	4	27.7	2.6	25.1	63.75413
5	7	2	5	28.8	4.4	24.4	61.97612
5	7	3	1	251.3	236.3	15	38.10008
5	7	3	2	251.5	241	10.5	26.67005
5	7	3	3	251	242.2	8.8	22.35204
5	7	3	4	251.4	242.6	8.8	22.35204
5	7	3	5	252	242.4	9.6	24.38405
5	7	4	1	103.9	88.4	15.5	39.37008
5	7	4	2	102	88.5	13.5	34.29007

5	7	4	3	101.3	90	11.3	28.70206
5	7	4	4	100.8	89.2	11.6	29.46406
5	7	4	5	101.6	89.8	11.8	29.97206
5	8	1	1	208.8	191.3	17.5	44.45009
5	8	1	2	209.6	190.2	19.4	49.2761
5	8	1	3	211.1	188.9	22.2	56.38811
5	8	1	4	210.3	189.4	20.9	53.08611
5	8	1	5	211	189.9	21.1	53.59411
5	8	2	1	116.1	90.3	25.8	65.53213
5	8	2	2	113.5	94	19.5	49.5301
5	8	2	3	111	99.5	11.5	29.21006
5	8	2	4	112.5	101.5	11	27.94006
5	8	2	5	113.5	95	18.5	46.99009
5	8	3	1	45.1	25.7	19.4	49.2761
5	8	3	2	44	27.6	16.4	41.65608
5	8	3	3	42.5	28	14.5	36.83007
5	8	3	4	43.1	27.2	15.9	40.38608
5	8	3	5	43.6	28.9	14.7	37.33807
5	8	4	1	211.4	201.5	9.9	25.14605
5	8	4	2	209.9	201.6	8.3	21.08204
5	8	4	3	210.9	201.8	9.1	23.11405
5	8	4	4	213	203.5	9.5	24.13005
5	8	4	5	214.2	205.1	9.1	23.11405

Table 9

Cross Sectional View Raw Data

Group	Unit	Side	Point	Value1	Value2	V1-V2	μm
1	1	1	1	5.8	4.8	1	2.54001
1	1	1	2	6.2	4.8	1.4	3.55601
1	1	1	3	5.9	3.8	2.1	5.33401
1	1	1	4	5.2	3.8	1.4	3.55601
1	1	1	5	4.2	3.2	1	2.54001
1	1	2	1	125.4	119.6	5.8	14.73203
1	1	2	2	124.6	119.5	5.1	12.95403
1	1	2	3	125.5	119.5	6	15.24003
1	1	2	4	125	119.1	5.9	14.98603
1	1	2	5	123.7	118.2	5.5	13.97003
1	1	3	1	209	203.8	5.2	13.20803
1	1	3	2	208.9	201.8	7.1	18.03404
1	1	3	3	210.3	203.8	6.5	16.51003
1	1	3	4	211.7	204.4	7.3	18.54204
1	1	3	5	212.5	205	7.5	19.05004
1	1	4	1	163.4	152.7	10.7	27.17805
1	1	4	2	163.8	158.3	5.5	13.97003
1	1	4	3	164.5	157.6	6.9	17.52604
1	1	4	4	164.9	152.5	12.4	31.49606
1	1	4	5	164.3	157.5	6.8	17.27203
1	2	1	1	154.8	146	8.8	22.35204
1	2	1	2	157.6	146.3	11.3	28.70206
1	2	1	3	160.7	147.2	13.5	34.29007
1	2	1	4	159	147	12	30.48006
1	2	1	5	157.2	145.4	11.8	29.97206
1	2	2	1	265	254.3	10.7	27.17805
1	2	2	2	17	3.9	13.1	33.27407
1	2	2	3	15.9	3.5	12.4	31.49606
1	2	2	4	15.8	3.8	12	30.48006
1	2	2	5	15.4	4	11.4	28.95606
1	2	3	1	120.8	111.3	9.5	24.13005
1	2	3	2	121.2	111.6	9.6	24.38405
1	2	3	3	121.9	111.8	10.1	25.65405
1	2	3	4	124	111.8	12.2	30.98806
1	2	3	5	125	110.6	14.4	36.57607
1	2	4	1	19.2	3.1	16.1	40.89408

1	2	4	2	20.4	3.9	16.5	41.91008
1	2	4	3	22.2	3.8	18.4	46.73609
1	2	4	4	22.7	4.3	18.4	46.73609
1	2	4	5	24.1	4	20.1	51.0541
1	3	1	1	54.2	40	14.2	36.06807
1	3	1	2	55.7	41	14.7	37.33807
1	3	1	3	55.6	41.5	14.1	35.81407
1	3	1	4	55.3	41.6	13.7	34.79807
1	3	1	5	54.4	40.8	13.6	34.54407
1	3	2	1	139.3	127.9	11.4	28.95606
1	3	2	2	135.3	126.4	8.9	22.60605
1	3	2	3	134.3	125.3	9	22.86005
1	3	2	4	129.6	125.7	3.9	9.90602
1	3	2	5	134.4	125.9	8.5	21.59004
1	3	3	1	158.3	150.7	7.6	19.30404
1	3	3	2	132.2	125.8	6.4	16.25603
1	3	3	3	132.6	124.5	8.1	20.57404
1	3	3	4	132.6	124.3	8.3	21.08204
1	3	3	5	131.4	124	7.4	18.79604
1	3	4	1	63.5	56.2	7.3	18.54204
1	3	4	2	61.8	56.8	5	12.70003
1	3	4	3	68.8	55.4	13.4	34.03607
1	3	4	4	66.2	55.4	10.8	27.43205
1	3	4	5	64.5	55.9	8.6	21.84404
1	4	1	1	41.3	37.3	4	10.16002
1	4	1	2	48.5	39	9.5	24.13005
1	4	1	3	48	39.5	8.5	21.59004
1	4	1	4	49.1	39.7	9.4	23.87605
1	4	1	5	49.6	38.8	10.8	27.43205
1	4	2	1	63.3	42.3	21	53.34011
1	4	2	2	63.2	42.3	20.9	53.08611
1	4	2	3	64.7	42.4	22.3	56.64211
1	4	2	4	64.6	42.2	22.4	56.89611
1	4	2	5	65.9	41.5	24.4	61.97612
1	4	3	1	180	156.3	23.7	60.19812
1	4	3	2	181.8	155.5	26.3	66.80213
1	4	3	3	182.9	157	25.9	65.78613
1	4	3	4	184.6	158.2	26.4	67.05613
1	4	3	5	186.8	157.5	29.3	74.42215
1	4	4	1	0	0	0	0
1	4	4	2	40.5	35.8	4.7	11.93802
1	4	4	3	47.1	37.7	9.4	23.87605

1	4	4	4	49.4	37.8	11.6	29.46406
1	4	4	5	49.8	38.2	11.6	29.46406
1	5	1	1	98.3	84.7	13.6	34.54407
1	5	1	2	99.4	95	4.4	11.17602
1	5	1	3	100.2	95.2	5	12.70003
1	5	1	4	100.3	95.7	4.6	11.68402
1	5	1	5	100.3	95.9	4.4	11.17602
1	5	2	1	42.7	40.2	2.5	6.35001
1	5	2	2	42.6	39.8	2.8	7.11201
1	5	2	3	42.6	39.3	3.3	8.38202
1	5	2	4	42.2	40	2.2	5.58801
1	5	2	5	42.1	38.6	3.5	8.89002
1	5	3	1	11.6	4.2	7.4	18.79604
1	5	3	2	11.2	4	7.2	18.28804
1	5	3	3	10	3.2	6.8	17.27203
1	5	3	4	11.2	2.4	8.8	22.35204
1	5	3	5	11	2	9	22.86005
1	5	4	1	0	0	0	0
1	5	4	2	0	0	0	0
1	5	4	3	0	0	0	0
1	5	4	4	0	0	0	0
1	5	4	5	44.2	42.5	1.7	4.31801
1	6	1	1	163.5	150	13.5	34.29007
1	6	1	2	160.5	151.2	9.3	23.62205
1	6	1	3	162.4	151.2	11.2	28.44806
1	6	1	4	161.4	151.2	10.2	25.90805
1	6	1	5	159	151.2	7.8	19.81204
1	6	2	1	196.7	187.3	9.4	23.87605
1	6	2	2	198.5	187.9	10.6	26.92405
1	6	2	3	198	187.3	10.7	27.17805
1	6	2	4	197.6	188.9	8.7	22.09804
1	6	2	5	197.3	189.2	8.1	20.57404
1	6	3	1	199.6	180.1	19.5	49.5301
1	6	3	2	201.9	179.9	22	55.88011
1	6	3	3	205.4	181	24.4	61.97612
1	6	3	4	202.8	179.5	23.3	59.18212
1	6	3	5	202.5	182.5	20	50.8001
1	6	4	1	117	58.5	58.5	148.5903
1	6	4	2	93.9	57.3	36.6	92.96419
1	6	4	3	79.8	57.1	22.7	57.65812
1	6	4	4	72.6	58.2	14.4	36.57607
1	6	4	5	71.5	57.5	14	35.56007

1	7	1	1	233.5	228.4	5.1	12.95403
1	7	1	2	234	228.1	5.9	14.98603
1	7	1	3	233.9	226.7	7.2	18.28804
1	7	1	4	234.3	227.1	7.2	18.28804
1	7	1	5	233	226.4	6.6	16.76403
1	7	2	1	0	0	0	0
1	7	2	2	0	0	0	0
1	7	2	3	0	0	0	0
1	7	2	4	0	0	0	0
1	7	2	5	0	0	0	0
1	7	3	1	253.6	250	3.6	9.14402
1	7	3	2	256.9	249.5	7.4	18.79604
1	7	3	3	260.9	248.5	12.4	31.49606
1	7	3	4	262.6	250.5	12.1	30.73406
1	7	3	5	265.1	251.6	13.5	34.29007
1	7	4	1	148.2	143	5.2	13.20803
1	7	4	2	150.6	142.3	8.3	21.08204
1	7	4	3	152.2	143.5	8.7	22.09804
1	7	4	4	152.8	143.3	9.5	24.13005
1	7	4	5	152	143.3	8.7	22.09804
1	8	1	1	258.4	254.3	4.1	10.41402
1	8	1	2	261.3	253.8	7.5	19.05004
1	8	1	3	260.9	254.2	6.7	17.01803
1	8	1	4	263.5	262.8	0.7	1.778
1	8	1	5	261.3	260.1	1.2	3.04801
1	8	2	1	181.7	176.2	5.5	13.97003
1	8	2	2	187.3	175.5	11.8	29.97206
1	8	2	3	191	175.7	15.3	38.86208
1	8	2	4	190.5	174.9	15.6	39.62408
1	8	2	5	189.3	176	13.3	33.78207
1	8	3	1	198.9	189.5	9.4	23.87605
1	8	3	2	198.8	189.5	9.3	23.62205
1	8	3	3	198	188.1	9.9	25.14605
1	8	3	4	198	188.1	9.9	25.14605
1	8	3	5	197.3	188.2	9.1	23.11405
1	8	4	1	197.5	188.9	8.6	21.84404
1	8	4	2	199	197.8	1.2	3.04801
1	8	4	3	199.9	188	11.9	30.22606
1	8	4	4	201	187.5	13.5	34.29007
1	8	4	5	201.3	186.7	14.6	37.08407
2	1	1	1	197	182.5	14.5	36.83007

2	1	1	2	200	183.6	16.4	41.65608
2	1	1	3	202.4	185	17.4	44.19609
2	1	1	4	204.5	183.8	20.7	52.57811
2	1	1	5	205.5	185.2	20.3	51.5621
2	1	2	1	212.3	208.5	3.8	9.65202
2	1	2	2	210.6	207.7	2.9	7.36601
2	1	2	3	211.3	207.3	4	10.16002
2	1	2	4	210.1	207.6	2.5	6.35001
2	1	2	5	208.5	206.7	1.8	4.57201
2	1	3	1	110	101.3	8.7	22.09804
2	1	3	2	109.4	101.3	8.1	20.57404
2	1	3	3	111.8	101.2	10.6	26.92405
2	1	3	4	108.9	101.3	7.6	19.30404
2	1	3	5	116.9	104.5	12.4	31.49606
2	1	4	1	0	0	0	0
2	1	4	2	0	0	0	0
2	1	4	3	0	0	0	0
2	1	4	4	128.5	125.7	2.8	7.11201
2	1	4	5	131.4	126.7	4.7	11.93802
2	2	1	1	37.2	33.3	3.9	9.90602
2	2	1	2	39.9	35	4.9	12.44602
2	2	1	3	34.1	33	1.1	2.79401
2	2	1	4	44.8	35	9.8	24.89205
2	2	1	5	50.7	34.3	16.4	41.65608
2	2	2	1	188.2	186.4	1.8	4.57201
2	2	2	2	188.1	185.9	2.2	5.58801
2	2	2	3	187.3	184.6	2.7	6.85801
2	2	2	4	187.4	183.9	3.5	8.89002
2	2	2	5	186.5	183.4	3.1	7.87402
2	2	3	1	198	196.5	1.5	3.81001
2	2	3	2	200	195.8	4.2	10.66802
2	2	3	3	198.5	195.5	3	7.62002
2	2	3	4	197.8	196.5	1.3	3.30201
2	2	3	5	199.3	196	3.3	8.38202
2	2	4	1	141.2	137.1	4.1	10.41402
2	2	4	2	140	135.2	4.8	12.19202
2	2	4	3	139.3	135.7	3.6	9.14402
2	2	4	4	139.5	134.9	4.6	11.68402
2	2	4	5	138	134.7	3.3	8.38202
2	3	1	1	256.5	253.2	3.3	8.38202
2	3	1	2	259.6	252.9	6.7	17.01803
2	3	1	3	263.3	253.8	9.5	24.13005

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2	3	1	5	272.2	253.8	18.4	46.73609
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2	3	2	2	87.3	84.6	2.7	6.85801
2	3	2	3	87.4	83.8	3.6	9.14402
2	3	2	4	86.4	83	3.4	8.63602
2	3	2	5	85.8	82.3	3.5	8.89002
2	3	3	1	69.9	66.3	3.6	9.14402
2	3	3	2	69.2	65.3	3.9	9.90602
2	3	3	3	69.2	63.3	5.9	14.98603
2	3	3	4	71.7	62.8	8.9	22.60605
2	3	3	5	73.5	63.2	10.3	26.16205
2	3	4	1	59.9	58.2	1.7	4.31801
2	3	4	2	58	56.8	1.2	3.04801
2	3	4	3	62.2	57.8	4.4	11.17602
2	3	4	4	70.7	58	12.7	32.25806
2	3	4	5	72.3	56.2	16.1	40.89408
2	4	1	1	178.7	175.5	3.2	8.12802
2	4	1	2	179.2	175.2	4	10.16002
2	4	1	3	180.1	175.9	4.2	10.66802
2	4	1	4	182.4	176	6.4	16.25603
2	4	1	5	184.5	175.9	8.6	21.84404
2	4	2	1	227.2	224.8	2.4	6.09601
2	4	2	2	228.5	224.8	3.7	9.39802
2	4	2	3	228.6	224.3	4.3	10.92202
2	4	2	4	227.8	224.3	3.5	8.89002
2	4	2	5	226.6	224	2.6	6.60401
2	4	3	1	14.3	10.3	4	10.16002
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2	4	3	3	12.7	11	1.7	4.31801
2	4	3	4	12.9	10.9	2	5.08001
2	4	3	5	11.9	10.4	1.5	3.81001
2	4	4	1	93.1	89.5	3.6	9.14402
2	4	4	2	92.9	89.3	3.6	9.14402
2	4	4	3	92.3	90.1	2.2	5.58801
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2	4	4	5	92.6	90.9	1.7	4.31801
2	5	1	1	204.3	194.8	9.5	24.13005
2	5	1	2	205.8	194.5	11.3	28.70206
2	5	1	3	206.2	195.4	10.8	27.43205
2	5	1	4	205.9	195.6	10.3	26.16205
2	5	1	5	206.3	195.8	10.5	26.67005

2	5	2	1	104	96.9	7.1	18.03404
2	5	2	2	105.7	97.3	8.4	21.33604
2	5	2	3	105.7	96.2	9.5	24.13005
2	5	2	4	116.8	96.7	20.1	51.0541
2	5	2	5	116	95.5	20.5	52.0701
2	5	3	1	14.8	9.3	5.5	13.97003
2	5	3	2	16.2	9.8	6.4	16.25603
2	5	3	3	16.7	9.9	6.8	17.27203
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2	6	1	2	204	179.8	24.2	61.46812
2	6	1	3	205.3	180.5	24.8	62.99213
2	6	1	4	208.3	180.6	27.7	70.35814
2	6	1	5	211.8	183.2	28.6	72.64415
2	6	2	1	161	158.9	2.1	5.33401
2	6	2	2	162.1	159.3	2.8	7.11201
2	6	2	3	162.8	160.9	1.9	4.82601
2	6	2	4	162.7	159.8	2.9	7.36601
2	6	2	5	164.3	160	4.3	10.92202
2	6	3	1	84.9	70.5	14.4	36.57607
2	6	3	2	84	70.6	13.4	34.03607
2	6	3	3	85.4	70.9	14.5	36.83007
2	6	3	4	81.8	71.5	10.3	26.16205
2	6	3	5	82.6	70.9	11.7	29.71806
2	6	4	1	92.2	86.8	5.4	13.71603
2	6	4	2	93.3	86.3	7	17.78004
2	6	4	3	94.2	86	8.2	20.82804
2	6	4	4	95.1	84.5	10.6	26.92405
2	6	4	5	95.2	84.7	10.5	26.67005
2	7	1	1	93.4	87.8	5.6	14.22403
2	7	1	2	90.5	86.3	4.2	10.66802
2	7	1	3	90.6	86.5	4.1	10.41402
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2	7	2	4	0	0	0	0
2	7	2	5	224	221.1	2.9	7.36601
2	7	3	1	85.2	78.1	7.1	18.03404
2	7	3	2	85.4	79.1	6.3	16.00203
2	7	3	3	85.8	79	6.8	17.27203
2	7	3	4	82.6	78	4.6	11.68402
2	7	3	5	80.9	77.5	3.4	8.63602
2	7	4	1	248	245.2	2.8	7.11201
2	7	4	2	248.5	244.9	3.6	9.14402
2	7	4	3	249.3	244.2	5.1	12.95403
2	7	4	4	248.9	243.2	5.7	14.47803
2	7	4	5	249.2	243.1	6.1	15.49403
2	8	1	1	84.8	76.1	8.7	22.09804
2	8	1	2	83.5	75.1	8.4	21.33604
2	8	1	3	84.3	75.1	9.2	23.36805
2	8	1	4	84.5	76.1	8.4	21.33604
2	8	1	5	85.6	76.3	9.3	23.62205
2	8	2	1	182.1	177.2	4.9	12.44602
2	8	2	2	181.1	175.2	5.9	14.98603
2	8	2	3	180.9	174.9	6	15.24003
2	8	2	4	181.1	174.7	6.4	16.25603
2	8	2	5	180	174.1	5.9	14.98603
2	8	3	1	28	25.5	2.5	6.35001
2	8	3	2	28.2	25.8	2.4	6.09601
2	8	3	3	29.2	25.6	3.6	9.14402
2	8	3	4	33.9	26	7.9	20.06604
2	8	3	5	37.8	26.2	11.6	29.46406
2	8	4	1	174.4	172.8	1.6	4.06401
2	8	4	2	177.3	173.3	4	10.16002
2	8	4	3	176.2	171.8	4.4	11.17602
2	8	4	4	176.2	172	4.2	10.66802
2	8	4	5	175.2	171.5	3.7	9.39802
3	1	1	1	188.4	163.6	24.8	62.99213
3	1	1	2	189	163.8	25.2	64.00813
3	1	1	3	189.3	163.5	25.8	65.53213
3	1	1	4	189	163.7	25.3	64.26213
3	1	1	5	189.3	164	25.3	64.26213
3	1	2	1	177.8	163.8	14	35.56007
3	1	2	2	177.2	167.2	10	25.40005
3	1	2	3	177.9	166.3	11.6	29.46406

3	1	2	4	186.8	165.3	21.5	54.61011
3	1	2	5	193.2	164.9	28.3	71.88214
3	1	3	1	180.5	177	3.5	8.89002
3	1	3	2	182.8	178.8	4	10.16002
3	1	3	3	184.3	178.8	5.5	13.97003
3	1	3	4	186.1	179.6	6.5	16.51003
3	1	3	5	187.5	178.8	8.7	22.09804
3	1	4	1	138	121.5	16.5	41.91008
3	1	4	2	137.8	123	14.8	37.59208
3	1	4	3	137.2	122.5	14.7	37.33807
3	1	4	4	131.5	122.8	8.7	22.09804
3	1	4	5	136.3	123	13.3	33.78207
3	2	1	1	236.6	211.3	25.3	64.26213
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3	2	1	3	236.8	211.7	25.1	63.75413
3	2	1	4	237.8	210.8	27	68.58014
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3	2	2	1	84.6	74.1	10.5	26.67005
3	2	2	2	83.8	74.6	9.2	23.36805
3	2	2	3	85	75	10	25.40005
3	2	2	4	84.4	74.9	9.5	24.13005
3	2	2	5	83.8	75	8.8	22.35204
3	2	3	1	243.1	239.3	3.8	9.65202
3	2	3	2	245.2	241.1	4.1	10.41402
3	2	3	3	245.8	241.2	4.6	11.68402
3	2	3	4	246.7	241.8	4.9	12.44602
3	2	3	5	246.6	241.5	5.1	12.95403
3	2	4	1	36.8	36	0.8	2.032
3	2	4	2	39.8	38.4	1.4	3.55601
3	2	4	3	44.7	38.2	6.5	16.51003
3	2	4	4	46.6	40.2	6.4	16.25603
3	2	4	5	48.5	39.8	8.7	22.09804
3	3	1	1	143	131.3	11.7	29.71806
3	3	1	2	144.3	132.2	12.1	30.73406
3	3	1	3	144.3	133	11.3	28.70206
3	3	1	4	144.3	133.8	10.5	26.67005
3	3	1	5	144.4	133.2	11.2	28.44806
3	3	2	1	78	72.8	5.2	13.20803
3	3	2	2	79.7	74.2	5.5	13.97003
3	3	2	3	79.3	73.3	6	15.24003
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3	3	2	5	84.8	73.5	11.3	28.70206

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3	3	4	3	126.5	108.2	18.3	46.48209
3	3	4	4	128.3	110	18.3	46.48209
3	3	4	5	130.9	110	20.9	53.08611
3	4	1	1	55.9	36.8	19.1	48.5141
3	4	1	2	56.3	36.6	19.7	50.0381
3	4	1	3	57.8	36.5	21.3	54.10211
3	4	1	4	57.8	35	22.8	57.91212
3	4	1	5	56.5	35.7	20.8	52.83211
3	4	2	1	65.6	61.3	4.3	10.92202
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3	4	3	4	49.9	37.5	12.4	31.49606
3	4	3	5	50.5	37.1	13.4	34.03607
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3	4	4	2	161.5	147.8	13.7	34.79807
3	4	4	3	164.9	149.1	15.8	40.13208
3	4	4	4	162.5	148.9	13.6	34.54407
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3	5	1	1	256.8	251	5.8	14.73203
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3	5	4	1	232.2	230.9	1.3	3.30201
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3	6	2	3	90.8	85.6	5.2	13.20803
3	6	2	4	89.4	82.3	7.1	18.03404
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3	6	3	4	203.8	201.6	2.2	5.58801
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3	7	1	3	121.1	112.8	8.3	21.08204
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3	7	3	1	150.8	148.2	2.6	6.60401
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3	7	3	3	151	146.4	4.6	11.68402

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3	7	4	2	171.6	168.5	3.1	7.87402
3	7	4	3	170.4	167.8	2.6	6.60401
3	7	4	4	170.3	166.7	3.6	9.14402
3	7	4	5	168.5	167.3	1.2	3.04801
3	8	1	1	226	220	6	15.24003
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3	8	4	2	161	159.5	1.5	3.81001
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3	8	4	5	166	157.9	8.1	20.57404
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4	1	1	4	42.5	32	10.5	26.67005
4	1	1	5	41.3	32.5	8.8	22.35204
4	1	2	1	75.1	72	3.1	7.87402
4	1	2	2	75.3	70.5	4.8	12.19202
4	1	2	3	76.2	69.8	6.4	16.25603
4	1	2	4	71.5	70.5	1	2.54001
4	1	2	5	77.8	68.7	9.1	23.11405
4	1	3	1	68.5	66.5	2	5.08001
4	1	3	2	69	66.6	2.4	6.09601
4	1	3	3	69.5	67.3	2.2	5.58801
4	1	3	4	69.4	67.3	2.1	5.33401
4	1	3	5	70	68.1	1.9	4.82601

4	1	4	1	10	8.2	1.8	4.57201
4	1	4	2	9.8	8.7	1.1	2.79401
4	1	4	3	9.7	8.2	1.5	3.81001
4	1	4	4	9.1	7.6	1.5	3.81001
4	1	4	5	7.2	6.5	0.7	1.778
4	2	1	1	224.2	218.1	6.1	15.49403
4	2	1	2	225.1	219.1	6	15.24003
4	2	1	3	224.2	219	5.2	13.20803
4	2	1	4	224.3	219	5.3	13.46203
4	2	1	5	224.9	219.3	5.6	14.22403
4	2	2	1	225.2	217.6	7.6	19.30404
4	2	2	2	224	218.2	5.8	14.73203
4	2	2	3	223.9	217.2	6.7	17.01803
4	2	2	4	219.5	216.9	2.6	6.60401
4	2	2	5	224.3	216.5	7.8	19.81204
4	2	3	1	146.4	144.5	1.9	4.82601
4	2	3	2	145	142.4	2.6	6.60401
4	2	3	3	145	142.2	2.8	7.11201
4	2	3	4	144	139.8	4.2	10.66802
4	2	3	5	143.2	138.9	4.3	10.92202
4	2	4	1	119.4	117.8	1.6	4.06401
4	2	4	2	119.4	116.4	3	7.62002
4	2	4	3	118.9	117	1.9	4.82601
4	2	4	4	118.3	116.3	2	5.08001
4	2	4	5	118.2	116.5	1.7	4.31801
4	3	1	1	147.2	134.5	12.7	32.25806
4	3	1	2	145.9	134.8	11.1	28.19406
4	3	1	3	146.3	135.5	10.8	27.43205
4	3	1	4	148.7	135.9	12.8	32.51207
4	3	1	5	146.1	135.3	10.8	27.43205
4	3	2	1	39.6	37.1	2.5	6.35001
4	3	2	2	40	36.1	3.9	9.90602
4	3	2	3	39.3	35.4	3.9	9.90602
4	3	2	4	40.5	36.8	3.7	9.39802
4	3	2	5	38	34.2	3.8	9.65202
4	3	3	1	180.5	173.8	6.7	17.01803
4	3	3	2	180.5	173.8	6.7	17.01803
4	3	3	3	174.9	172.9	2	5.08001
4	3	3	4	0	0	0	0
4	3	3	5	172.7	171.1	1.6	4.06401
4	3	4	1	135.2	122.1	13.1	33.27407

4	3	4	2	135.1	123	12.1	30.73406
4	3	4	3	136.5	123	13.5	34.29007
4	3	4	4	136.8	122.3	14.5	36.83007
4	3	4	5	136.8	122.3	14.5	36.83007
4	4	1	1	102	91.2	10.8	27.43205
4	4	1	2	101.3	94.3	7	17.78004
4	4	1	3	102.4	95.8	6.6	16.76403
4	4	1	4	101.8	94.3	7.5	19.05004
4	4	1	5	101.9	93.5	8.4	21.33604
4	4	2	1	153.5	151.7	1.8	4.57201
4	4	2	2	152.6	150	2.6	6.60401
4	4	2	3	152.8	150.9	1.9	4.82601
4	4	2	4	154.6	151.9	2.7	6.85801
4	4	2	5	155.6	151.5	4.1	10.41402
4	4	3	1	115	100.8	14.2	36.06807
4	4	3	2	113.7	99.5	14.2	36.06807
4	4	3	3	104	100.4	3.6	9.14402
4	4	3	4	105.2	99.6	5.6	14.22403
4	4	3	5	103.4	99.1	4.3	10.92202
4	4	4	1	145.6	143.4	2.2	5.58801
4	4	4	2	145.3	141.9	3.4	8.63602
4	4	4	3	145.3	142.5	2.8	7.11201
4	4	4	4	145.3	142.3	3	7.62002
4	4	4	5	144.9	142.5	2.4	6.09601
4	5	1	1	0	0	0	0
4	5	1	2	0	0	0	0
4	5	1	3	239.9	238.4	1.5	3.81001
4	5	1	4	247.3	238.2	9.1	23.11405
4	5	1	5	250.2	237.8	12.4	31.49606
4	5	2	1	0	0	0	0
4	5	2	2	0	0	0	0
4	5	2	3	0	0	0	0
4	5	2	4	0	0	0	0
4	5	2	5	0	0	0	0
4	5	3	1	77	71.3	5.7	14.47803
4	5	3	2	76.2	71.4	4.8	12.19202
4	5	3	3	76.3	70.3	6	15.24003
4	5	3	4	77.4	70	7.4	18.79604
4	5	3	5	77.3	69.8	7.5	19.05004
4	5	4	1	0	0	0	0
4	5	4	2	0	0	0	0
4	5	4	3	0	0	0	0

4	5	4	4	0	0	0	0
4	5	4	5	0	0	0	0
4	6	1	1	89	85.8	3.2	8.12802
4	6	1	2	90.8	86.3	4.5	11.43002
4	6	1	3	92.5	87.4	5.1	12.95403
4	6	1	4	93.8	87.7	6.1	15.49403
4	6	1	5	96.8	85.7	11.1	28.19406
4	6	2	1	252.7	248.3	4.4	11.17602
4	6	2	2	253.5	248.9	4.6	11.68402
4	6	2	3	253.8	249.3	4.5	11.43002
4	6	2	4	255.7	249	6.7	17.01803
4	6	2	5	254.8	250	4.8	12.19202
4	6	3	1	7.9	6.2	1.7	4.31801
4	6	3	2	8.3	5	3.3	8.38202
4	6	3	3	8.1	4.8	3.3	8.38202
4	6	3	4	9.1	5.2	3.9	9.90602
4	6	3	5	8.9	3.8	5.1	12.95403
4	6	4	1	37.3	28.8	8.5	21.59004
4	6	4	2	38	30	8	20.32004
4	6	4	3	37.6	29.8	7.8	19.81204
4	6	4	4	38	28.7	9.3	23.62205
4	6	4	5	37.9	29.1	8.8	22.35204
4	7	1	1	105	99.5	5.5	13.97003
4	7	1	2	104.2	100.2	4	10.16002
4	7	1	3	107.6	101.8	5.8	14.73203
4	7	1	4	111.2	101.4	9.8	24.89205
4	7	1	5	114.5	102	12.5	31.75006
4	7	2	1	73.3	68	5.3	13.46203
4	7	2	2	71.8	68.2	3.6	9.14402
4	7	2	3	73.2	67.7	5.5	13.97003
4	7	2	4	72.3	68.4	3.9	9.90602
4	7	2	5	74.2	68.1	6.1	15.49403
4	7	3	1	201	195.4	5.6	14.22403
4	7	3	2	200	195.1	4.9	12.44602
4	7	3	3	201.7	195.2	6.5	16.51003
4	7	3	4	202.3	195.1	7.2	18.28804
4	7	3	5	204.6	195.2	9.4	23.87605
4	7	4	1	17.8	4	13.8	35.05207
4	7	4	2	14.5	2.8	11.7	29.71806
4	7	4	3	15	3.7	11.3	28.70206
4	7	4	4	14.8	2.5	12.3	31.24206
4	7	4	5	15.1	2.9	12.2	30.98806

4	8	1	1	90.1	69.9	20.2	51.3081
4	8	1	2	89.9	69.9	20	50.8001
4	8	1	3	87	69	18	45.72009
4	8	1	4	84.7	69.3	15.4	39.11608
4	8	1	5	82.5	68.8	13.7	34.79807
4	8	2	1	112.1	99.2	12.9	32.76607
4	8	2	2	111.4	99	12.4	31.49606
4	8	2	3	111.6	98.7	12.9	32.76607
4	8	2	4	111.2	98.6	12.6	32.00406
4	8	2	5	111.4	99	12.4	31.49606
4	8	3	1	34.5	29.9	4.6	11.68402
4	8	3	2	35.4	31.2	4.2	10.66802
4	8	3	3	36.3	30.5	5.8	14.73203
4	8	3	4	35	29.5	5.5	13.97003
4	8	3	5	36.3	30.2	6.1	15.49403
4	8	4	1	199.5	196.3	3.2	8.12802
4	8	4	2	200.3	196	4.3	10.92202
4	8	4	3	200.2	196.1	4.1	10.41402
4	8	4	4	200.8	196	4.8	12.19202
4	8	4	5	200.3	195.5	4.8	12.19202
5	1	1	1	245	229.5	15.5	39.37008
5	1	1	2	243.9	229.4	14.5	36.83007
5	1	1	3	243.6	229.3	14.3	36.32207
5	1	1	4	244.6	228.8	15.8	40.13208
5	1	1	5	244	229.2	14.8	37.59208
5	1	2	1	191.3	178.4	12.9	32.76607
5	1	2	2	195.8	179.9	15.9	40.38608
5	1	2	3	193.9	177.1	16.8	42.67209
5	1	2	4	195	177.8	17.2	43.68809
5	1	2	5	194.2	177.2	17	43.18009
5	1	3	1	250.2	240	10.2	25.90805
5	1	3	2	249.1	240.8	8.3	21.08204
5	1	3	3	253.3	240.7	12.6	32.00406
5	1	3	4	254.5	240.3	14.2	36.06807
5	1	3	5	254.9	239.8	15.1	38.35408
5	1	4	1	142.9	140.7	2.2	5.58801
5	1	4	2	143.9	141	2.9	7.36601
5	1	4	3	144.8	141.5	3.3	8.38202
5	1	4	4	143.5	141	2.5	6.35001
5	1	4	5	142.4	141.1	1.3	3.30201
5	2	1	1	177.8	170.9	6.9	17.52604

5	2	1	2	178.3	172.5	5.8	14.73203
5	2	1	3	179	173.3	5.7	14.47803
5	2	1	4	181.2	173	8.2	20.82804
5	2	1	5	179.7	173.3	6.4	16.25603
5	2	2	1	151.5	142	9.5	24.13005
5	2	2	2	153.4	144.7	8.7	22.09804
5	2	2	3	155	145.8	9.2	23.36805
5	2	2	4	153.2	146.2	7	17.78004
5	2	2	5	150.8	147.2	3.6	9.14402
5	2	3	1	100.3	96.2	4.1	10.41402
5	2	3	2	100.2	96	4.2	10.66802
5	2	3	3	103.6	95.8	7.8	19.81204
5	2	3	4	105.2	95.9	9.3	23.62205
5	2	3	5	103.5	96.3	7.2	18.28804
5	2	4	1	132.2	123.2	9	22.86005
5	2	4	2	133.1	123.1	10	25.40005
5	2	4	3	129.6	122.1	7.5	19.05004
5	2	4	4	128.2	122.1	6.1	15.49403
5	2	4	5	129.5	121.5	8	20.32004
5	3	1	1	152.2	149.1	3.1	7.87402
5	3	1	2	152	148.8	3.2	8.12802
5	3	1	3	151.7	149.2	2.5	6.35001
5	3	1	4	153.5	150	3.5	8.89002
5	3	1	5	159	151.2	7.8	19.81204
5	3	2	1	0	0	0	0
5	3	2	2	0	0	0	0
5	3	2	3	0	0	0	0
5	3	2	4	39.2	27	12.2	30.98806
5	3	2	5	39.1	26.5	12.6	32.00406
5	3	3	1	165.2	163	2.2	5.58801
5	3	3	2	166.2	163.9	2.3	5.84201
5	3	3	3	167.2	163.7	3.5	8.89002
5	3	3	4	166.4	163	3.4	8.63602
5	3	3	5	165.8	163	2.8	7.11201
5	3	4	1	0	0	0	0
5	3	4	2	18.1	10.2	7.9	20.06604
5	3	4	3	21	12.5	8.5	21.59004
5	3	4	4	22.8	11.8	11	27.94006
5	3	4	5	23.3	13.5	9.8	24.89205
5	4	1	1	124	96.6	27.4	69.59614
5	4	1	2	124.3	96.2	28.1	71.37414
5	4	1	3	126.1	95	31.1	78.99416

5	4	1	4	128.4	96.4	32	81.28016
5	4	1	5	130.8	96.4	34.4	87.37617
5	4	2	1	13.5	10	3.5	8.89002
5	4	2	2	13.9	11.2	2.7	6.85801
5	4	2	3	15.5	10.9	4.6	11.68402
5	4	2	4	11.4	10.7	0.7	1.778
5	4	2	5	17.1	10.3	6.8	17.27203
5	4	3	1	243.4	236.3	7.1	18.03404
5	4	3	2	244.6	237.9	6.7	17.01803
5	4	3	3	247	240.2	6.8	17.27203
5	4	3	4	243.8	239.3	4.5	11.43002
5	4	3	5	251.2	242.5	8.7	22.09804
5	4	4	1	58.9	55.9	3	7.62002
5	4	4	2	59.1	54.6	4.5	11.43002
5	4	4	3	59.2	54.2	5	12.70003
5	4	4	4	59.2	54.5	4.7	11.93802
5	4	4	5	61.2	54.3	6.9	17.52604
5	5	1	1	63.8	54.2	9.6	24.38405
5	5	1	2	64.5	54.8	9.7	24.63805
5	5	1	3	63.2	55	8.2	20.82804
5	5	1	4	63.2	54.9	8.3	21.08204
5	5	1	5	63.8	53.7	10.1	25.65405
5	5	2	1	125.8	124.8	1	2.54001
5	5	2	2	126	124.3	1.7	4.31801
5	5	2	3	126	125	1	2.54001
5	5	2	4	127.6	123.5	4.1	10.41402
5	5	2	5	128.2	123.6	4.6	11.68402
5	5	3	1	188.6	185.1	3.5	8.89002
5	5	3	2	190.4	186.3	4.1	10.41402
5	5	3	3	190.4	185.8	4.6	11.68402
5	5	3	4	192.1	186.1	6	15.24003
5	5	3	5	192.7	185.6	7.1	18.03404
5	5	4	1	151.2	144.6	6.6	16.76403
5	5	4	2	155	145.1	9.9	25.14605
5	5	4	3	155.8	146.3	9.5	24.13005
5	5	4	4	156.3	147.1	9.2	23.36805
5	5	4	5	157.2	147	10.2	25.90805
5	6	1	1	256.1	247.3	8.8	22.35204
5	6	1	2	256.2	246.2	10	25.40005
5	6	1	3	258.5	247.4	11.1	28.19406
5	6	1	4	260.2	248.8	11.4	28.95606
5	6	1	5	260.8	246.3	14.5	36.83007

5	6	2	1	102.8	98.1	4.7	11.93802
5	6	2	2	103.3	96.9	6.4	16.25603
5	6	2	3	103.1	96.4	6.7	17.01803
5	6	2	4	103.1	96.2	6.9	17.52604
5	6	2	5	103.3	95.7	7.6	19.30404
5	6	3	1	242.6	241	1.6	4.06401
5	6	3	2	243.3	241.8	1.5	3.81001
5	6	3	3	244.4	242.1	2.3	5.84201
5	6	3	4	246	242.9	3.1	7.87402
5	6	3	5	246.8	243.3	3.5	8.89002
5	6	4	1	125.2	122.7	2.5	6.35001
5	6	4	2	127.7	124.6	3.1	7.87402
5	6	4	3	127.8	124	3.8	9.65202
5	6	4	4	127.5	123.1	4.4	11.17602
5	6	4	5	127.6	125.5	2.1	5.33401
5	7	1	1	104.7	100.2	4.5	11.43002
5	7	1	2	104.8	100.2	4.6	11.68402
5	7	1	3	105.6	99.8	5.8	14.73203
5	7	1	4	107.3	99.9	7.4	18.79604
5	7	1	5	107.8	99.8	8	20.32004
5	7	2	1	230.2	226.8	3.4	8.63602
5	7	2	2	228.3	225.6	2.7	6.85801
5	7	2	3	237.6	233.3	4.3	10.92202
5	7	2	4	238	228.7	9.3	23.62205
5	7	2	5	238.3	233.5	4.8	12.19202
5	7	3	1	159.2	156.7	2.5	6.35001
5	7	3	2	159.6	157.1	2.5	6.35001
5	7	3	3	160.9	156.8	4.1	10.41402
5	7	3	4	162.3	156.9	5.4	13.71603
5	7	3	5	163.2	155.8	7.4	18.79604
5	7	4	1	103	98.4	4.6	11.68402
5	7	4	2	104.3	97.5	6.8	17.27203
5	7	4	3	105	97.3	7.7	19.55804
5	7	4	4	105.5	98.2	7.3	18.54204
5	7	4	5	105.3	96.5	8.8	22.35204
5	8	1	1	141.3	135	6.3	16.00203
5	8	1	2	144.6	134.5	10.1	25.65405
5	8	1	3	149.4	134.6	14.8	37.59208
5	8	1	4	150.9	134.3	16.6	42.16408
5	8	1	5	148.3	134.9	13.4	34.03607
5	8	2	1	7.8	5.9	1.9	4.82601

5	8	2	2	9	5.8	3.2	8.12802
5	8	2	3	8.8	7.3	1.5	3.81001
5	8	2	4	7.2	3.3	3.9	9.90602
5	8	2	5	6.5	2.8	3.7	9.39802
5	8	3	1	86.2	79.6	6.6	16.76403
5	8	3	2	84	79.2	4.8	12.19202
5	8	3	3	83	78.3	4.7	11.93802
5	8	3	4	82.5	76.9	5.6	14.22403
5	8	3	5	81.4	75.5	5.9	14.98603
5	8	4	1	28.8	19.9	8.9	22.60605
5	8	4	2	30	18.5	11.5	29.21006
5	8	4	3	31.5	18	13.5	34.29007
5	8	4	4	30.5	11.8	18.7	47.49809
5	8	4	5	30	16.6	13.4	34.03607

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